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TAXONOMIC CHARACTERS OF THE GENERA ALTERNARIA AND MACROSPORIUM

BY

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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY JOHN ASBURY ELLIOTT

ENTITLED TAXONOMIC CHARACTERS OF THE GENERA ALTERNARIA AND MACROSPORIUM.

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

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TAXONOMIC CHARACTERS OF THE GENERA ALTERNARIA AND MACROSPORIUM

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I. INTRODUCTION

Alternaria and Macrosporium are among the most universally distributed and most common forms of the Fungi Imperfecti, embracing, according to the "Sylloge Fungorum" of Saccardo, 41 species and varieties of Alternaria and 189 species and varieties of Macrosporium; these numbers including some synonyms but not the new species which have been described since the publication of the last volume of Saccardo's work. Some species, such as Alternaria solani, A. brassicae v. nigrescens, and Macrosporium sarcinaeforme, are well known and destructive parasites, but the great majority are saprophytes or have been described from non-important hosts. The ascigerous stages of a few species are known, the connection in all such cases being with the genus Pleospora.

Macrosporium and Alternaria are placed by reason of their muriform spores in the section Dictyosporae of the family Dematiaceae of the order Moniliales; the muriform spores separating them from the genera Cladosporium and Helminthosporium, which in some species are in many particulars similar. Among the Dictyosporae there is little basis, as the genera are described, for separating Stemphylium, or Mystrosporium from Macrosporium. Clements, in his key, places Mystrosporium as a synonym under Macrosporium. The separation of the genera Alternaria and Macrosporium rests on the catenulation of spores in the former genus. The fact that many of the species of Alternaria now recognized were first described as Macrosporiums indicates the uncertainty of this basis

for generic distinction. In the specific descriptions in both genera; while mycelium, conidiophores, and spores may all be taken into consideration; spore characters are the most used basis for distinction.

A tabulation of the species and varieties given in the "Sylloge Fungorum" was made on the basis of spore length, the species being arranged according to the maximum length given. Both length and breadth are expressed graphically. As many as possible of the other characters are expressed numerically. (Table A.).

In order to learn something of the variation in measurements which may be due to the personal element and to the use of different micrometers and microscopes in measuring, three slides were prepared and together with cultures of Phoma destructiva Pa., were sent to a number of persons actively engaged in descriptive mycological work. On one slide of Pleurosigma angulatum a single frustule was enclosed in a circle and indicated; on a second slide two spores of Alternaria fasciculata were similarly indicated. A third slide of A. fasciculata contained several hundred spores. The request was made that the size of these be given as would ordinarily be done in describing a new species. Identical typewritten directions were sent to each one who made the measurements, asking that no more care be used than would ordinarily be taken in measuring for the purpose of describing a new species.

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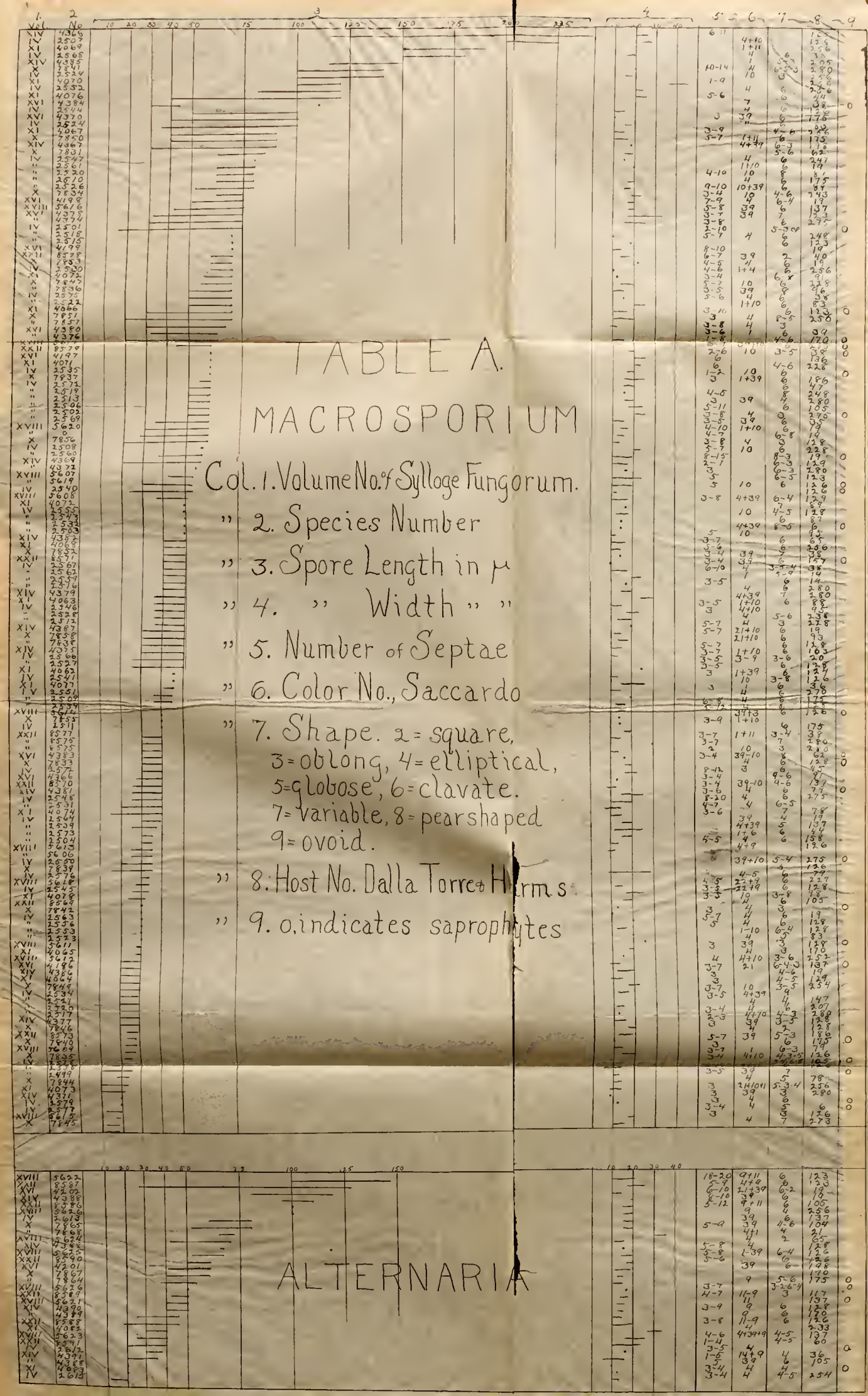
TABLE A.
MACROSPORIUM
Col. 1. Volume No. of Sylloge Fungorum.
" 2. Species Number
" 3. Spore Length in μ
" 4. " Width " "
" 5. Number of Septae
" 6. Color No., Saccardo
" 7. Shape. 2 = square, 3 = oblong, 4 = elliptical, 5 = globose, 6 = clavate. 7 = variable, 8 = pearshaped 9 = ovoid.
" 8. Host No. Dalla Torre & Harms
" 9. 0. indicates saprophytes
ALTERNARIA

A tabulation of results follows:

Table B.

Observer No.	Eye-piece value	Single Frustule of P. angulatum	One spore of Alternaria	One spore of Alternaria	Many Spores of Alternaria	Many Spores of Phoma
1	2.4	285.6 x 45.6	48 x7.2	19.2 x 9.6	12-36 x 6-12	2-5 x 1-2
2	2.4	284.4 x 46.8	49.2 x 6	19.2 x 9.6	14-36 x 9-12	3-4 x 2-3
3	1.8	284.4 x 45.9	50.6 x 7.2	19.8 x 9.9	11-41 x 6-13	
4	3.16	282 x 46.5	48 x 7.5	19.5 x 9.5	10.5-24 x 7.5-13	5-6 x 1.5-2
5	3.4	282 x 46	48 x 7	20 x 10	17-34 x 7-10	
6	3.2	280 x 45	48 x 7	20 x 7	13-29 x 9-11	4-8 x 2-3.5
7	.4	280 x 44	48 x 7	20 x 9	20x9	5-6 x 2-2.5
8	3.2	276 x 45	48 x 8	21 x 7	12-35 x 9-12	
9	10.	275 x 50			13-35 x 7-11	
10	3.2	275 x 45	47 x 7	20 x 10	12-33 x 6-12	3-8 x 2-3
11	3.	270 x 48	50 x 7.5	21 x 9.5	15-40 x 8-12	5-8 x 3-5
	Variation	15.6 x 6	3.6 x 2	1.8 x 3	6.5-17 x 3-3	3-4 x 2-3
	" in %	5- x 12	7 - x 25	8.5-x 30	43--41- x 33-23	60-44- x 66-60
12	2.8 *	218.8 x 38.4	39.5 x 5.6	15.1 x 8.4	8-27 x 6-11	

The second column gives the value of the smallest division of each eyepiece micrometer in micromillimeters. All the measurements given in the table are in microns. The arrangement is according to the maximum measurement given for Pleurosigma angulatum.

*This report was not considered in averaging and discussing the variations on account of an evident error in the valuation of the eye-piece micrometer.

The third, fourth and fifth columns show the variations in measurements when all, without any doubt, were measuring the

things. The variation is least in the longest measurements, being a little over 5% in the greatest length given, and greatest in one of the two shortest measurements, amounting to 30% in the width of the spore indicated in the fifth column. That this variation is not due to the eyepiece used is shown by the fact that observer No. 10 who returned the lowest measurement for the long spore, (column 4), also returned the highest measurement for the width of the spore given in column five. The variations given for the Phoma spores are the greatest, being 66% for the shortest measurement and 44% for the longest measurement. In this case each mycologist made his own microscopic preparation.

Mr. F. E. Kempton of the University of Illinois, in studying this species found that the measurements of 200 spores on the same medium that was sent to the mycologists returning the above results, were as follows; the range being from 3 to 9 microns:

(size	3 mu	4 mu	5 mu	6 mu	7 mu	8 mu	9 mu
(frequency	2,	23,	75,	64,	28,	5,	3.

It will be seen that the combined results in table B. column 7, cover the entire range found in the careful measurements of 200 spores, by Mr. Kempton, although those who gave one extreme without the other did not give a dependable impression of the size of the spores.

The most instructive results appear in the sixth column of the table where the maximum and minimum lengths and breadths of the spores are given under conditions such as would obtain in describing a new species; and directions were given that the measurements were to be made as if for that purpose. Here there was a variation of over 41% of the highest maximum measurement returned for the length of the spores. The variation for the minimum lengths

was greater, which might be partially explained by assuming that some mycologist rejected the smaller spores as immature or atypical.

Assuming variation equal to that shown in column 6 of table B, 34 species of Macrosporium and 5 species of Alternaria in table A, are inseparable by measurements of both length and breadth. If the measurements from columns 4 and 5, which are of spores from the same culture are taken into consideration, 48 species of Macrosporium and 9 species of Alternaria are inseparable on a basis of the spore measurements made by the eleven different mycologists. If added to this we take into consideration the possibilities of such evident error as the last line of the table shows, the dependability of measurements in identifying species becomes of very little value, especially when within narrow limits.

Applying to the whole of table A, the variability shown in column 6 of table B, all of the species given in the tabulation can be combined into thirteen groups, taking into consideration the measurements for both length and breadth of spores. In other words, in so far as actual spore measurements are dependable and are the only serviceable characters, there are only thirteen species of Macrosporium and Alternaria adequately described in the "Sylloge Fungorum."

Following the study of descriptions in the "Sylloge Fungorum", examination was made of the specimens of Macrosporium and Alternaria in the exsiccati immediately available. 134 specimens labeled as 85 species, were found. Of this number 17 were marked "sp. n." ie., of or nearly of the value of type material. Eighteen other species not marked "sp. n." were found in the exsiccati of the authors or one of the joint authors of the species. This gave a total of 35 species the material of which can be regarded

as reasonably authentic.

Mounts were made from each of the specimens, from which spore and conidiophore measurements, and the character of each, were recorded. The nature of the growth, whether apparently parasitic or saprophytic, was also recorded and the descriptions so made were compared. There was no doubt that in the collection, many specimens morphologically indistinguishable appeared under different names, and that in some instances the same name was given to specimens which were in no way similar or which could readily be distinguished from each other.

In the following summary of the study of the exsiccati the names are given as they appeared on the specimen, followed by the title of the collection and the number of the specimen in the collection. Two asterisks * * following the species name indicates that the specimen was marked "sp. n."; a single asterisk * indicates that the specimen was found in the exsiccati of the author of the species.

Group 1.

The following species had only globular or packet shaped spores and were essentially alike:

Macrosporium sarcinaeforme* Cavara, Fungi Par., Bri. & Cav., 116.

M. cladisporioides Dmz., Fungi Sel. Ex., Roum., 5596.

M. stilbosporideum B. & C., N. Am. Fungi, Ellis, 2080.

A second group was made of those having globular or packet shaped spores like those of the first group, but having in addition some ovate or pointed spores which might be due to variation in the shape of spore or to a mixture of two forms:

M. parasiticum* * Thum, Myc. Univ. Thum., 667; Fungi Par., B and C., 152.

M. consortiale* * Thum., Myc. Univ. Thum., 1373.

M. sarcinula Berk., Fungi Col., 3032.

M. chartarum Pk., N. Am. Fungi, 648; Fungi Sel. Ex., Roum., 6560.

M. heteronemum (Dmz.) Sacc. Fungi Sel. Ex., Roum., 6647, 6562, 6358.

The following were possibly the same as the above but they either showed minor differences or else the material was not sufficient to afford positive judgment:

M. chartarum, Pk., Fungi Colum., 396.

M. zimmermaneii Thum., Fungi Sel. Ex., Roum., 396.

M. polytrichum Cke. & Rav., Fungi Par. , Bri. & Cav., 191.

M. puccinioides E. & A., N. Am. Fungi, 2876.

Group 3.

A third group was made of species having long, narrow, regular, tapering spores with few longitudinal septa. All were apparently parasitic:

M. euphorbiae* * Bart., Fungi Colum., 2633.

M. carotae* E. & E., N. Am. Fungi, Ellis, 3289; Fungi Colum., 2632.

M. amaranthi Pk., Fungi. Colum., 2631.

M. brassicae f. solani, Fungi Sel. Ex., Roum., 6559.

M. cheiranthi Fr., Fungi Am., Rav., 303.

M. solani E. & M., Fungi Colom., 891; 398; 3635; Fungi. Par., Bri., & Cav., 191; Economic Fungi, Seymour & Earle, 339; 340; N. Am. Fungi, Ellis, 1265; 2485.

Alternaria solani (E. & M.) J. & G. Econ. Fungi, Sey. & Earle, 521.

A. brassicae (Berk.) Sacc., Fungi Par., Bri. & Cav., 87.

Two forms similar to the above were:

M. caudatum* C. & E., Fungi Colum., 397. Like the above but uniformly shorter.

M. antennaeforme B. & C., Fungi. Colum., 2531. This species was in general form similar to those in the above group but the spores were uniformly more slender.

Group 4.

Three other specimens were found with spores of the same form as the above group but the spores were much larger. These were:

M. herculeum* E. & M., N. Am. Fungi, Ellis, 1263.

M. commune* Rabh., Fungi Europ., Rabh., 1360.

M. saponariae Pk., N. Y. Fungi, Shear, 397; Fungi Sel. Ex., Roum., 3868.

Group 5.

Another group was formed of species with spores similar to those of Alternaria solani but generally wider and shorter and always more markedly muriform. The species in this group are not morphologically identical but merely similar.

M. heteroschemon* * Faut., Fungi Sel. Ex., Roum., 6942.

M. cucumerinum* E. & E., N. Am. Fungi, Ellis, 3396.

M. nervii Cke., N. Am. Fungi, Ellis, 964.

M. sucaviae Trabut., Fungi Sel. Ex., Roum., 4098.

M. convallariae Fr., Fungi Sel. Ex., Roum., 1897.

M. brassicae Berk., Fungi Sel. Ex., Roum., 6442.

M. martindalei E. & M., N. Am. Fungi, Ellis, 1262; Fungi Europ., Rabh., 3282.

M. cheiranthi Fr., Fungi Sel. Ex., Roum., 7235.

Alternaria malvae* Roum., Fungi. Sel. Ex., Roum., 3393.

A. brassicae (Berk.) Sacc., Econ. Fungi, Sey. & Earle, 515.

Group 6.

In the following group the specimens are essentially all alike; quite variable in color, shape, and size. The color varied from light to dark olive both in spores and conidiophores. Almost all appeared to be growing saprophytically.

M. hibiscinum* * Thum., Myc. Uni., Thum., 979.

M. baptisiae* * Thum., Myc. Uni., Thum., 1271; Fungi Sel. Ex., Roum., 4897.

M. cassiaecolum* * Thum., Myc. Uni., Thum., 1270; Fungi Sel. Ex., Roum., 4795.

M. gossypinum* * Thum., Myc. Uni., Thum., 1469; Fungi Sel. Ex., Roum., 4898.

M. ravenelii* * Thum., Myc. Uni., Thum., 2071; Fungi Sel. Ex., Roum., 4680.

M. rubi* * Ellis, N. A. Fungi, Ellis, 544.

M. truncatum* * Laub. & Faut., Fungi. Gallici, Roum., 6752.

M. inquinans* C. & E., N. Am. Fungi, 369.

M. ornatissimum* E. & B., Fungi Colum., 1741.

M. porri,* C. & E., Fungi Colum., 1279; N. Am. Fungi, 370;

M. caudatum* C. & E., Fungi Am., Rav., 607; Fungi Colum., 890; Fungi Colum., 397; N. Am. Fungi, 816.

M. iridis* C. & E., N. Am. Fungi, 51.

M. canificans* Thum., inid, Myc. Uni. Thum., 2280; Fungi. Gall. Ex., Roum. 4794.

M. leguminum* Cke., Fungi Am., Rav., 300; Fungi Am., Rav., 603.

M. maydis* C. & E., N. Am. Fungi, 3098; Rabh-Winter, Fungi Europ., 3592.

M. catalpae* E. & M., N. Am. Fungi, 1264; Econ. Fungi, Sey. & Earle, 144.

M. martindalei* E. & M., N. Am. fungi, 1262.

M. tomato Cke.,* N. Am. Fungi, 2484; Fungi Am., Rav., 603.

M. tenuissimum Fries, Myc. Uni., Thum., 989.

M. convallariae Fr., Myc. Univ., Thum., 1965.

M. chartarum pk., Fungi Colum., 396.

M. floridanum Cke., Fungi Am., Rav., 299.

M. florigenum E. & D., N. Am. Fungi, 3097.

M. lagenariae Thum., Fungi Colum., 1367.

M. Clematis Pk., Fungi Col., 1830.

M. bulbotrichum Cke. Fungi Am., Rav. 604.

M. erumpens Cke., Fungi Am., Rav., 605.

M. graminium Cke., Fungi Am., Rav., 606.

M. caespitulum Cke., Fungi Am., Rav., 906.

M. cheiranthi, Cke., Fungi Sel. Ex., Roum., 4490.

M. consortiale Thum., Fungi Sel. Ex., Roum., 4992.

M. saponariae Pk., Fungi Sel. Ex., Roum., 3868.

M. phomoides Thum., Fungi Sel. Ex. Roum., 6145.

M. caespitulorum Rabh., Fungi Sel. Ex., Roum., 7236.

M. fasciculatum C. & E., Fungi Sel. Ex., Roum., 1058; N. Am. Fungi, 52; Fungi Colum., 399; Myc. Univ., Thum., 1870.

M. commune Rabh., Fungi Sel. Ex., Roum., 2068, 4239, 3288, 6443; Fungi Am. Rav. 304; Fungi Colum., 2330; N. Am. Fungi, Ellis, 418;

Alternaria fasciculata (C. & E.) J. & G., Econom. Fungi, Sey. & Earle, 522; Fungi Colum., 1368.

Except for being lighter colored, M. peponicolum* * Rabh., Fungi Europ., Rabh., 1285, was like those in the above group. Several others were in most particulars like the above but either differed in some respects or else the material was too scanty for judgement. These were:

M. abruptum* C. & E., N. Am. Fungi, Ellis, 127; Fungi Am., Rav., 302.

M. phaseoli,* * Faut., Fungi Sel. Ex., Roum., 6247.

M. cercosporoides* C. & E., Fungi Colum., 1740.

M. valerianellae* Roum., Fungi Sel. Ex., Roum., 3590.

M. elegantissimum* Rabh., Fungi Europ., 2883; Fungi Sel. Ex., Roum., 2067.

M. concinum B. & Br., Fungi Sel. Ex., Roum., 6443.

M. commune Rabh., Fungi. Sel. Ex., Roum., 4240.

M. puccinioides E. & And., Fungi Colum., 1172.

Group 7.

Two quite similar species which differed from any other

specimens were:

M. junci* * Lamb. & Faut., Fungi Sel. Ex., Roum., 6444.

M. brassicae B., Fungi Sel. Ex., Roum., 2363; N. Am. Fungi, Ellis, 2483.

They were like Alternaria brassicae v. microspora, which the latter undoubtedly was.

One species, A. cucurbitae* * Let. & Roum., Fungi Sel. Ex., Roum., 3694. did not afford enough material for judgement.

The above study of exsiccati and descriptions brings not only species into question but genera as well, since in all but the first and second of the above groups both Alternaria and Macrosporium are included in groups as morphologically similar.

II. HISTORICAL.

The genus Alternaria was described and figured by Nees,[18] A. tenuis being the type and only species described. The description is incomplete and in some particulars inaccurate, but it is definite and complete enough to leave little doubt that what Nees saw and described was what is now generally recognized as Alternaria.

Fries[17] described the genus Macrosporium, differentiating it from Cladosporium, Helminthosporium, and Sporodesmium. The muriform spore, now given as one of the characters of the genus, is not mentioned in the generic description, otherwise it fits the present current conception fairly well. Having dropped the genus Alternaria, Fries makes no mention of it in his description of Macrosporium.

The keys at present used, base the separation of the two genera solely upon the catenulation of spores in the genus Alternaria.

The question of the validity of the separation of the two genera arose over the study of their ascigerous connection with Pleospora herbarum. The Tulasne brothers[1] figure P. herbarum bearing both Alternaria and sarcinaeform spores on the same hyphae. Gibelli and Griffini,[2] Mattirolo,[3] Bauk,[4] and Kohl,[5] studying P. herbarum in pure culture, concluded that it should be divided into two varieties or species, one having Alternaria conidia and the other having sarcinaeform conidia. Miyake,[6] studying the life history of Macrosporium parasiticum found no Alternaria stage in the life cycle. Halsted[7] in studying the life history of Pleospora tropaeoli in pure culture, found that the cycle included only Pleospora and Alternaria stages.

As the ascigerous stage of most species of Alternaria and Macrosporium is unknown or non-existent the basis for the distinction of genera and species must rest, in general, on the conidia. Jones[8-9] in studying Macrosporium solani and M. fasciculatum on artificial media found that they formed chains of conidia and placed them in the genus Alternaria. Biolette[10] reported securing pure cultures of Macrosporium sp. and Alternaria sp. from olives in California. Others[11] have reported isolating species of one or the other genera from various sources and growing them in pure culture under conditions where the morphology of the fungi ought to be pretty certainly ascertained, but by far the greatest amount of literature on the two genera deals with their pathogenic effects or with the mere description of species.

Miyake,[6] Prillieux and Delacroix,[12] and others[13] have shown by careful experiments or have suggested that many of the specific names are synonyms. Constantin[13] and Planchon[14] have reported great variations in Alternaria due to growth on different

media. Planchon[14] expresses the opinion that Macrosporium is merely Alternaria with dissociated conidia. No extensive comparative work, either between the two genera or between species of the two genera, has yet been undertaken.

In the light of the preceeding brief survey of the present status of the genera Alternaria and Macrosporium, comparative studies of a number of species of both genera, with the hope of gaining further knowledge of both the generic and specific limitations, become very desirable. The studies undertaken by the writer were made with this in view. The work was necessarily limited to a few species and the result is in no way in the nature of a monograph of the genera, but it is hoped that it may add to the knowledge of the genera in question and form the basis for further work.

III. METHODS IN GENERAL.

Cultures of Alternaria and Macrosporium and material upon which either was growing were secured from many sources.* Of eighty cultures thus obtained all but two produced chains of spores in culture and accordingly belong in the genus Alternaria. All of these had clavate, elongate or ovate, more or less pointed spores. The two which did not produce chains of spores had globular or sarcinaeform conidia. Eleven of the cultures were selected as representative of

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*Cultures or material was received from J. J. Davis, L. R. Jones, B. F. Lutman, W. G. Sackett, S. M. Tracy, H. T. Güssow, E. C. Stakman, G. P. Clinton, M. T. Cook, J. F. Atkinson, B. D. Halsted, I. M. Lewis, C. W. Edgerton, C. R. Orton, B. B. Higgins, J. W. Eastham, Miss Jean MacInnes, G. L. Peltier.

all the forms present and accordingly being most suitable for intensive study. These eleven cultures also represented all of the morphological forms found in exsiccati. They were: Alternaria solani. (E. & M.) J. & G., isolated from blighted potato leaves; A. solani isolated from Datura leaf spot; A. brassicae v. nigrescens Peglion, isolated from blighted cantaloupe leaves; A. brassicae v. microspora (Berk.) Sacc., isolated from cabbage leaf spot; A. fasciculata (C. & E.) J. & G., isolated from potato leaf spot; A. tenuis Nees, isolated from decaying wood; A. dianthi Stev. & Hall, isolated from Dianthus leaf spot; A. iridicola (E. & E.) n. com., (Macrosporium iridicolum E. & E.) isolated from iris leaf spot; A. sonchi Davis, (in lit.) isolated from leaf spot of Sonchus asper; Macrosporium sarcinaeforme Cavara, isolated from clover leaf spot; M. sarcinula Berk., isolated from decayed spot on Jonathan apple.

All studies were made with pure cultures originating from a single spore of each species used, the spores being located on thin poured plates and transferred before germinating to other plates. The instruments invented by Keitt* greatly facilitated this operation.

Whenever it was possible to do so, ten-day-old cultures were used as the standard for comparisons. Measurements of spores and conidiophores were made whenever present. In measuring spores a mechanical stage was used and every spore on the slide which came within the field was measured for both length and width, thus eliminating unconscious selection. Curves of the measurements of each hundred spores and also a combined curve of four hundred spores were

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*Phytopothology 5: 266, 1915.

made for each culture. In twenty such measurements of four hundred spores it was found that the curve for each of the four separate hundred covered the same range of variation and were so nearly alike that when they were superimposed they practically coincided. For this reason it was decided to use one hundred measurements as the basis for the extremes of variation and the average size of the spores under any one given condition. Since in a given species there is frequent variation in the length of the beaks, from one third to six or seven times the length of the spores, the beaks were not in any case included in the measurements.

Tables giving the superimposed curves of the measurements of one hundred spores of the same species under different conditions were prepared for the sake of easy comparison of the variations due to differences in cultural conditions. (Tables 1-11.).

IV. EXPERIMENTS.

Host Relation and Parasitism

Inoculations were made on the natural hosts, on their near relatives and on other plants when there seemed to be any advantage in so doing. For example, Alternaria solani which is morphologically similar to A. brassicae was inoculated on cabbage leaves. Macrosporium sarcinula, which has been said to be identical with M. parasiticum on onions, was inoculated on onion tops.

The plants were inoculated by needle pricks and by placing spores in drops of water on the unbroken leaf surface. The percentage of successful inoculations was estimated from the needle pricks since these were more easily located. An inoculation was considered successful if the fungus to a notable degree invaded and killed the tissues surrounding the punctures. Unless otherwise

stated, successful inoculations also occurred on the unbroken leaf surface. To check the results of the needle-prick inoculations, sterile needle pricks were always made and all the plants kept under identical conditions. In no case did the control plants show signs of fungus invasion around the needle pricks. They will receive no further mention. Unless otherwise stated, spores of the fungus used were always re-isolated from the spots caused by the inoculations. In the following tables the terms "normal" and "characteristic" indicate that the spot or fungus appeared the same as in the cases of natural infection.

Alternaria solani from potato leaves: Inoculations were made from the first and tenth generations on agar and from spores taken directly from potato leaf spots. The mycelium was used as the inoculum since very few spores were produced in culture. All of the inoculations with mycelium were made by needle pricks on plants under bell jars.

No.	Inoculum	Inoculated on	Results	Remarks
1	spores from potato leaf	potato leaves	+ 100%	characteristic spot
2	" " " "	Datura "	+ 50%	" "
3	" " " "	tomato "	+ 100%	" "
4	" " " "	Solanum nigrum leaves	+ 100%	" "
5	pure culture on agar 1st generation mycelium	potato leaves	+ 100%	" "
6	pure culture on agar 1st generation mycelium	Datura leaves	+ 100%	" "
7	"	tomato "	+ 100%	" "
8	"	Solanum nigrum leaves	+ 100%	" "
9	"	cabbage leaves	+ 50%	very slow growth
10	"	iris "	-	
11	"	Lactuca canadensis leaves	-	
12	"	radish leaves	-	
13	10th generation mycelium on agar	potato leaves	+ 100%	characteristic spot
14	"	Datura "	+ 100%	" "
15	"	cabbage "	+ 100%	slow growth
16	"	tomato fruit	+ 100%	black sunken spot

The development of the spots was less rapid on Datura than on any other of the Solanaceous hosts. (Plate IV: 6, 7, 8. Plate V: 1, 2.) Spots were all of the characteristic "target board" type. Very few spores were produced on any of the spots, - none on the cabbage leaf. (Plate III: 14.)

A. solani from Datura leaves: Inoculations by needle pricks and on the uninjured leaf surface were made with spores taken direct-

ly from leaf spots and with spores of the first and tenth generations from agar plates. All plates were kept under bell jars.

No.	Inoculum	Inoculated on	Results	Remarks
1	Spores from Datura leaf	Datura leaves	+ 8%	characteristic spots
2	" " " "	tomato "	+ 16%	" "
3	" " " "	potato "	+ 25%	" "
4	" " " "	Solanum nigrum	+ 8%	" "
5	Pure Culture Gen. 1	Datura leaves	+ 100%	" "
6	" " " "	tomato "	+ 100%	" "
7	" " " "	potato "	+ 100%	" "
8	" " " "	Solanum nigrum	+ 100%	" "
9	" " " 10	Datura leaves	+ 100%	" "
10	" " " "	potato leaves	+ 100%	" "
11	" " " "	cabbage "	-	
12	" " " "	tomato fruit	+ 100%	black sunken spot.

The fungus developed least vigorously on potato leaves. On the other Solanaceous hosts the spots were not different from those caused by A. solani from potato leaves. (Plate IV: 1, 2, 4, 5. Plate V: 3, 4.) Very few spores were produced on any of the spots.

A. brassicae v. nigrescens from cantaloupe leaves: Inoculations were made with small pieces of diseased tissue, also with spores from the first, sixth and tenth generation on agar; by means of needle pricks and on the uninjured surface. The plants were kept under bell jars for the first few days following inoculations.

No.	Inoculum	Inoculated on	Results	Remarks
1	diseased tissue	cantaloupe leaf	+ 100%	characteristic spot
2	pure culture 1st gen. spores	" "	+ 100%	" "
3	" "	cabbage "	+ 25%	small spots
4	" "	Datura "	-	
5	" "	Lactuca canadensis	-	
6	10th gen.spores	cantaloup leaf	+ 100%	characteristic spots

The spots produced on cantaloupe leaves appearing in 2 or 3 days were characteristic and developed rapidly. The spots on cabbage leaves were mere dots where the spores had germinated on the unbroken leaf surface, but of considerable size where punctures were made. No spores were produced on cabbage and very few on cantaloupe leaves.

A. brassicae v. microspora from cabbage leaf spots: All inoculations were made with spores from pure cultures, by needle pricks or on unbroken leaf surface.

No.	Inoculum	Inoculated on	Results	Remarks
1	Spores from pure culture	cabbage leaves	+ 100%	finally destroyed the plants
2	" " " "	radish "	+ 100%	" "
3	" " " "	sweet alyssum"	+ 100%	" "
4	" " " "	potato leaves	-	
5	" " " "	Datura "	-	
6	" " " "	tomato "	-	
7	" " " "	ripe tomato fruit	+ 100%	made soft rot, black on surface
8	" " " "	Dianthus leaves	-	
9	" " " "	green tomato fruit	-	

The fungus produced characteristic concentric spots with dark rings of spores on the surface. (Plate IV: 9, 10.) Spores spread the fungus to other parts of susceptible plants until they were entirely destroyed. The spots on ripe tomatoes were dark with narrow sharply defined zones of spores.

A. fasciculata from potato leaf spots: Inoculations were made with spores by means of needle pricks and on the unbroken leaf surface.

No.	Inoculum	Inoculated on	Results	Remarks
1	spores from agar plate	potato leaves	-	
2	" " " "	tomato "	-	
3	" " " "	lettuce "	-	
4	" " " "	cabbage "	-	
5	" " " "	radish "	-	
6	" " " "	ripe tomato fruit	+ 100	soft decay spots covered with mycelium
7	" " " "	green tomato fruit	-	
8	" " " "	etiolated cabbage leaves	+ 50%	definite circular spots
9	" " " "	" potato leaves	+	spread over all weakened parts
10	" " " "	" tomato "	+	spread over wilted leaves
11	" " " "	" radish "	-	
12	" " " "	" lettuce "	+	spread on dead parts
13	" " " "	Dianthus "	-	

The only definite spots of parasitic appearance were from needle pricks on etiolated or partially etiolated cabbage leaves. (Plate IV: 3.) The spores and conidiophores on the cabbage leaf spots were very light amber in color, instead of dark olive as is normal. In the other cases the tissues attacked may have been dead before the fungus appeared on them. (Plate III:

15.) In ripe tomatoes a hard black core was formed in the interior as the mycelium invaded the tissues. This was surrounded by a soft decayed area.

A. tenuis from decaying wood: Only one series of inoculations was attempted with this species. This was made on Dianthus leaves by means of needle pricks. No spots were formed. The inoculations were made on Dianthus because A. tenuis spores can not be distinguished from those of A. dianthi.

A. dianthi from Dianthus leaf spots: Inoculations were made both by needle pricks and on unwounded leaf surface with spores of the first and fifth generations from agar plates.

No.	Inoculum	Inoculated on	Results	Remarks
1	spores from agar 1 gen.	Dianthus leaves	+ 100%	characteristic spots
2	" " " " "	cabbage "	-	
3	gen. 5 from agar	Dianthus "	+ 100%	plant finally killed by fungus.

In air of natural humidity the spots remained very small but under a bell jar they spread rapidly producing concentive rings of dark spores on the surface.

A. iridicola from iris leaf spots: Inoculations were made entirely by means of needle pricks. Both spores and mycelium were used.

No.	Inoculum	Inoculated on	Results	Remarks
1	spores from agar	iris leaves	+ 100%	characteristic spots
2	" " "	Lillium "	-	
3	" " "	Datura "	-	
4	" " "	potato "	-	
5	" " "	cabbage "	-	
6	" " "	cantaloupe "	-	
7	" " "	Lactuca canadensis	-	
8	" " "	onion leaves	+ 50%	large rapidly advancing spot

Spots on iris extended slowly, on onion tops, more rapidly accompanied by the production of a considerable number of spores. (Plate V: 6-10.) Inoculations were made on Datura, potato, cabbage, and cantaloupe because of the general resemblance of the spores of A. iridicola to A. solani. (Plate I, B: Fig. 7.).

A. sonchi from leaf spots on Sonchus asper: The fungus could not be isolated from the spots on Sonchus asper since the spores would not germinate in culture. Crude inoculations were made on Lactuca canadensis, using as the inoculum diseased leaf fragments of S. asper. These inoculations were successful and the production of spores on L. canadensis abundant. Pure cultures were obtained from the spots on L. canadensis. Inoculations were made by needle pricks and on the unbroken leaf surface.

No.	Inoculum	Inoculated on	Results	Remarks
1	diseased material	L. canadensis	+ 100	rapidly growing spots
2	spores from pure culture	" "	+ 100	" "
3	" " "	L. crispa	+ ?	small spots
4	" " "	dandelion	+ ?	" "
5	" " "	chrysanthemum	+ ?	" "
6	" " "	cabbage	-	
7	" " "	Datura	-	
8	" " "	potato	-	

On L. canadensis very rapidly spreading characteristic dark brown spots were formed in two days. (Plate IV: 11.) On cultivated lettuce, dandelion, and chrysanthemum distinct spots were formed around needle prick inoculations, but soon ceased to grow and no spores were produced. Spores production was abundant on L. canadensis. (Plate I, B: Fig. 8.).

Macrosporium sarcinaeforme from leaf spots on red clover: Inoculations were made with spores, both on the unwounded leaf surface and by needle pricks.

No.	Inoculum	Inoculated on	Results	Remarks
1	pure culture	red clover	+ 100%	characteristic spots
2	" "	white clover	+ 100%	lighter colored than on red clover
3	" "	alfalfa	+ 100%	" " "
4	" "	cow peas	-	
5	" "	cantaloupe	-	
6	" "	vetch	+ ?	did not form a definite spot
7	" "	Mimosa	-	
8	" "	onion	+ ?	small white spots

Spots developed most rapidly on red clover and spores scattered the disease over the entire plant. On white clover and alfalfa the spots did not spread to leaves that had not been inoculated. In all cases the spots appeared within three days of inoculation. On onion, small white spots were occasionally produced around needle pricks but no spores were produced and the parasitism was evidently very feeble. (Plate III: 13. Plate V: 11.).

M. sarcinula from apple fruit spot: This fungus was isolated by Miss Jean Mac Innes of the University of Illinois, in her studies on the rots of apples. It appeared to be causing an apple rot. Small black pycnidia-like bodies were scattered frequently over the rotted area under the epidermis of the apple. These also appeared in the first generation on agar. When broken they appeared to be merely sclerotia. The fungus conformed to descriptions and figures of M. sarcinula. Spores from pure cultures were used in making inoculations both by needle pricks and on uninjured leaf surface.

No.	Inoculum	Inoculated on	Results	Remarks
1	pure culture spores	red clover	+ 40%	vigorous spots
2	" " "	white clover	-	
3	" " "	alfalfa	+ 16%	slowly developing spots
4	" " "	vetch	-	
5	" " "	cabbage	-	
6	" " "	Datura	-	
7	" " "	Lillium	-	
8	" " "	onion	?	small white spot surrounding punctures
9	" " "	red clover	+ 100%	vigorous spots
10	" " "	apple	-	

All attempts to inoculate apples failed. The spots on red clover were lighter colored but otherwise almost identical with those caused by M. sarciniaeforme. (Plate III: 12.). Few spores were produced on the spots. On the onion tops the fungus produced small white spots surrounding the punctures but no spores were produced. (Plate V: 12, 13.).

The most noteworthy results of the inoculation experiments occurred in respect to A. solani, A. sonchi, A. brassicae v. nigrescens, and M. sarcinula. Both strains of A. solani grew freely on all of the Solanaceous hosts, and one strain was feebly parasitic on cabbage. Morphologically, judging from exsiccati, A. solani and A. brassicae are identical, and the inoculation esperiments might be considered further evidence of this view. A. sonchi was actively parasitic on Lactuca, a near relative of Sonchus, and was possibly very feebly parasitic on other Compositae. A. brassicae v. nigrescens proved slightly parasitic on cabbage although this would hardly be expected either from nearness of Cruciferae and Cucurbitaceae or from the morphology of A. brassicae and A. brassicae v. nigrescens which are readily distinguishable. M. sarcinaeforme and M. sarcinula are entirely dissimilar except in general form of spores, yet they appeared equally parasitic on red clover and alfalfa, and both were feebly parasitic on onion tops. A. brassicae and A. brassicae v. microspora are in no respect morphologically similar altho both are parasitic on the same host.

In studies of rots of apples, Miss Jean Mac Innes* isolated from cores or fruit spots of apples, several strains of Alternaria which were morphologically alike, although some produced rots from inoculations while others did not.

* unpublished thesis.

Cultures on Agar.

For purposes of isolation and general study, standard lima bean agar, (beans 100g., agar 15 G., water 1000 G.), was used. The cultures were kept in darkness at 30° C., with the exception that A. sonchi which would not grow at 30° was grown at 20°. In testing the effect of a lower temperature cultures on standard bean agar were kept at 10° C. The effects of acidity and alkalinity were determined on standard bean agar, using 30 cc. and 20 c.c. of normal hydrochloric acid, or 20 c.c. of normal sodium carbonate per liter. A standard synthetic agar was used to study the effect of nutrition: 1.36 g. acid potassium phosphate; 1.06 g. sodium carbonate, .5 g. magnesium sulphate, 5. g. glucose, 1. g. asparagin, 15 g. agar, 1000. g. water. Variations from this standard were made by omitting glucose, doubling the amount of glucose, omitting asparagin, and by doubling the amount of asparagin. Plain agar; 15. g. per liter of water, washed for several days in distilled water, was also used.

Records of all cultures on the various media were made in tabular form, but for the sake of brevity only the table for cultures on bean agar is given here; the differences shown on other media being briefly summarized. Variations in size of spores are given in tables 1 to 11 following the plates.

Cultures on bean agar, 30° c. 10 days.

BEAN AGAR 30° 10 days.

Fungus	Growth	Zonation General Character	Aerial Mycelium	Submerged Mycelium	Conidiophores	Spores
Alternaria solani from potato	33 mm.	Pure white, wide zoned, medium colored brick red	Abundant, long white, cottony	Colorless, straight	none	none
A. solani from Datura	33-35 mm.	gray, wide zoned colony no chromogensis	abundant, long white	Dark olive, much branched and torulose	Abundant normal or much constricted.	Abundant normal in size, but much constricted
A. brassicae v. nigrescens	42 mm.	Very dark, especially near the center	Very little, white	Dark olive, straight	Few, dark olive, normal	Few, dark Olive, normal
A. brassicae v. microspora	28-30 mm	Black colony with narrow sharply defined zonation	Very little, short, white, weak.	Colorless or nearly so, straight.	Abundant light-olive, normal	Very abundant, normal
A. fasciculata	32mm.	Gray, wide zoned	Abundant, white long.	Colorless, turning olive with age, straight.	Abundant light olive	Very abundant normal
A. tenuis	27 mm.	Dark in center, pale on outer edge, zonation well defined.	Little, white, long	Colorless at first, turning olive, straight.	Not abundant, light olive	Fairly abundant normal
A. dianthi	15-16 mm.	Gray, zoned colony	Considerable, long, white.	Colorless, or very light, olive, straight	Abundant, light olive	Abundant normal
A. iridicola	15-17 mm.	White or gray, cottony, zonation ill defined.	long, white, cottony.	Colorless, straight	Fairly abundant very pale olive	Fairly abundant, normal, l. olive
A. sonchi	25 mm. 20°C.	Pure white, cottony colony with dense mycelial zone, slight yellow chromogensis	Very abundant, white, cottony	Colorless, straight	In clumps very pale olive, normal.	In clumps under myc elial zones smaller than normal
Macrosporium sarcinaeforme	10-12 mm.	Black, dense colony	Very little, short white, weak.	Dark olive, much branched and torulose	Abundant dark, normal	Abundant dark olive normal
M. sarcinula	10-13 mm.	Cottony, white	Abundant, long white, cottony.	Colorless, straight	Abundant, light olive normal	Abundant, Olive, normal

The most striking characters brought out by the colonies on the standard bean agar were the wide differences in the two strains of A. solani which on their hosts are indistinguishable. The strain from potato produced a pure white colony with marked red chromogensis in the medium, had straight colorless submerged mycelium, and no spores. On account of the abundant production of conidiophores and spores the strain of A. solani from Datura formed a gray colony, it produced no chromogensis and the submerged mycelium was dark olive and torulose. A. fasciculata, A. tenuis, and A. dianthi produced spores indistinguishable from each other. The conidiophores of A. dianthi were slightly larger in cross section than those of the other two. In general appearance of the colonies and in the production of aerial mycelium these three species were different. The other Alternaria species studied were quite distinct in most cultural characters. The two species of Macrosporium were totally unlike except in general form of spores. (Plate II: 1, 3, 5, 7, 11, 13, 15. Plate III: 1, 3, 5, 7.).

Bean agar, 10°, 30 days.

Zonation was absent or inconspicuous in most of the colonies, especially in those of A. brassicae v. microspora, which at 30° had the most marked zonation of all the species.
This species also showed a marked alteration in color and form of its spores, these being light amber, nearly colorless and about half the width of the normal dark olive spores. Another marked change occurred in the size and color of the spores of A. dianthi, these being twice their normal dimensions and of much lighter color. (Plate I, A: 10.). A marked change in the character of both the aerial and submerged mycelium, (and size of spores, Table 10: c.)

occurred in M. sarcinaeforme, which is normally black, but here was white. All colonies were much retarded in rate of growth, the amount varying with the species. (Plate II: 2, 4, 6, 8, 12, 14, 16. Plate III: 2, 4, 6, 8.).Five produced no spores.

Bean agar + 30 Fuller's scale, 30°, 10 days.

This medium did not solidify and in many cases the whole colony was saturated with it. There was little variation in the general appearance of most of the colonies from that on standard bean agar. Two variations worthy of note were the absence of zonation in colonies of A. brassicae v. microspora, and the more than usual production of aerial mycelium, on colonies of A. brassicae v. nigrescens. The chromogensis of A. solani from potato was more marked on this than on any other medium. Some species which usually produced spores in more or less abundance produced few spores or none on this medium. They were: A. brassicae v. nigrescens, M. sarcinula. The spores of A. sonchi and M. sarcinula were below normal size.

Bean agar - 20 Fuller's scale, 30°, 10 days.

Except for a little greater production of aerial mycelium by most species, the general appearance of the colonies was like those on neutral bean agar. Chromogensis of A. solani was very marked, the media having more of a yellow tinge than on neutral agar;also the submerged mycelium of this species was darker than normal. A. brassicae v. nigrescens, M. sarcinaeforme and M. sarcinula produced fewer spores than on neutral agar.

Bean agar - 20 Fuller's scale, 30°, 10 days.

On the alkaline bean agar the most notable feature was the abundant production of spores by A. brassicae v. nigrescens, which ordinarily produced few spores on artificial media or on its

natural host. In this instance the spores covered all parts of the colony. A. solani from potato, which on neutral and acid media produced marked chromogensis, on the alkaline medium produced none and the submerged mycelium which on other bean agars was colorless, in the older part of the colonies became dark. A. dianthi, and M. sarcinula produced spores smaller than normal on the alkaline medium (Tables 7 & 11: E.). The general appearance of the colonies was little different from that on neutral bean agar with the exceptions already noted.

Standard synthetic medium, 30°, 10 days.

Except for a general lack of aerial mycelium and the appearance of less luxuriance, the colonies were little different from those on the standard lima bean agar.

Standard synthetic agar minus glucose. 30°, 10 days.

The appearance of the colonies on the synthetic agar without glucose was very similar to that on washed plain agar, although the appearance of starvation was not so emphasized. There was a little more color in the submerged mycelium and a little greater production of aerial mycelium than on leached agar. The character of the spores and conidiophores remained normal or nearly so. The only notable feature in a single species was that in colonies of A. solani from Datura, the spores had the same regular smooth appearance as when found on the natural host and were not deeply constricted as they are on other media.

Standard synthetic agar with double amount of glucose, 30° 10 days.

The aerial parts of the colonies, mycelium, conidiophores and spores were more abundant than on the standard medium. The size of the spores of some species was much reduced. (Tables 4, 8,

9, 11. curve H.)

Standard synthetic agar with double amount of asparagin, 30°, 10 days.

All colonies appeared less luxuriant than on the standard synthetic agar or bean agar.

Standard synthetic agar minus asparagin, 30°, 10 days.

Partial starvation appeared in all species, and the submerged mycelium was darkened in most cases. The latter was most noticeable in A. solani from potato, which usually has colorless mycelium. This same fungus produced a few spores on this medium, which was also unusual. Aerial mycelium was generally very meager in all species. In A. brassicae v. nigrescens, growth was retarded.

Plain washed agar, 20°.

But for the mycelium of Macrosporium sarcinaeforme, the only characters by which the different species could be identified were those of the spores and conidiophores which were natural. (Plate I, A: 1, 3, 5, 7, 8, 11, 16, 17. B: 7, 9.). Aerial mycelium was lacking and the submerged mycelium colorless and without distinctive features. Spores and conidiophores were characteristic. This was the only artificial medium upon which A. solani from potato produced spores in any abundance. A. solani, from Datura, did not produce spores until after eighty days. The torulose mycelium characteristic of this strain on most media was scarcely noticeable on the washed agar. Macrosporium sarcinaeforme produced dark torulose submerged mycelium characteristic of the species.

Variations Due to Humidity.

The effect of humidity upon the colony characters was studied by keeping the cultures at 20° C. in saturated atmosphere, room humidity (variation 45 - 70%), and in an atmosphere, kept dry

by the use of calcium chloride. In order to prevent dessication of the medium,all the plates were coated with a thin layer of paraffin. After the plates had been poured and the agar hardened, hot sterile paraffin was poured on the agar and after completely covering the agar the excess was poured off. This left a thin film of paraffin effectively protecting the medium from dessication or contamination. The paraffin was punctured in several places by needle pricks and spores of the fungi planted in one of the punctures. The cultures were kept with the plates inverted, without covers. In no case was there any contamination after the plates had been coated with paraffin and very little occurred during the process of coating. In the least humid atmosphere there appeared to be no change in the water content of the medium even after sixty days.

In all cases where aerial mycelium was produced, there was an increase in its production in the saturated atmosphere over that under ordinary conditions. Those species producing the greatest abundance of mycelium produced proportionately fewer spores. On account of the presence of the paraffin film, the usual colony form was lacking. A. brassicae v. microspora and M. sarcinaeforme, both of which produced almost no aerial mycelium, produced an abundance of spores. At room humidity little mycelium was produced, and that in tufts around the needle pricks; the relative production of spores was greater than in the saturated atmosphere; the submerged mycelium grew rapidly under the paraffin and covered the plate. In some cases the conidiophores ruptured the paraffin coat. This was true of M. sarcinaeforme, to a greater extent than of any other species. In the very dry atmosphere no aerial mycelium and no spores were produced with the exception that M. sarcinaeforme, produced a few spores in air bubbles in the paraffin coating. If a

plate was removed from the dry atmosphere and allowed to produce mycelium, then put back into the dry chamber, the mycelium at once shriveled, although the submerged parts of the colonies grew as usual.

Reaction to Bacterial Influence.

One species of bacteria, which I will designate as B. x, occasionally occurred as a contamination on plates. It had a marked inhibitory action upon the growth of the fungi and was therefore used for special study. Plantings of all the species of fungi that were being studied were made in the usual way, then after four days the plates were inoculated on four sides at about 1 mm. from the outer edge of the colonies with cultures of B. coli, 2 strains, B. subtilis, and B. x.

In all cases the fungi grew through the colonies of B.coli without showing any reaction. Occasionally in colonies of B.subtilis there was slight darkening of the mycelium. On the sides of the fungous colonies opposed to the colonies of B. x, however, there was in every case a marked reaction by the submurged mycelium. (Plate I, B: 6. Plate II: 10). The hyphae were inhibited greatly in growth, were much darkened and extremely torulose. Nodules were produced along the hyphal threads and at the extremities of hyphal branches. The reaction by all the fungi was essentially the same, although there were slight differences in the abnormal mycelium. In all cases there was no resemblance between the normal and the abnormal mycelium (Plate I, B: figs. 1-6). The aerial parts of the colonies did not show any reaction to the bacterial influence.

Chromogensis on Rice.

On account of the chromogensis exhibited by two of the species, cultures were made on boiled rice (1 g. rice, 10 g. water

autoclaved at 120° C. in test tubes). The colonies were allowed to grow for two months before comparisons were made, altho it was noted that, A. solani, from potato, A. sonchi, and M. sarcinula showed more or less marked chromogensis within three or four days after inoculation.

The most marked variations were those between the two strains of A. solani, which throughout the other experiments had shown many differences in reaction to media. A. solani from potato colored the rice light orange red at the bottom of the test tube, deep orange-red or brick-red at the lower limit of mycelial growth. The part of the rice through which the mycelium grew was dark-red-brown. The aerial mycelium was also red-brown. A. solani from Datura did not color the medium below the mycelium. The part of the medium occupied by the colony was dark gray or black. The aerial mycelium was white. A. sonchi colored the medium lemon yellow; A. iridicola, yellow brown; A. fasciculata, A. tenuis, and A. dianthi light brown; A. brassicae v. nigrescens gave a very faint brown; A. brassicae v. microspora gave no coloration. The medium was colored deep pink by Macrosporium sarcinaeforme; blue-gray by M. sarcinula.

The remarkable thing about the reactions of these fungi to various media is that it is impossible to predict from the reaction of one species, what the reaction of another will be. A case in point is the reaction to alkaline and acid media. A. brassicae v. nigrescens showed a gradual increase in production of spores from high acid to alkaline media, the production in the latter case being very abundant. A. solani, from Datura, produced very few spores on the alkaline media while on the acid media the spore production was abundant. Several species showed a lowered spore production in the

acid media, notably those which normally produced few spores. Macrosporium sarcinaeforme, which usually produced spores in great abundance, produced none on the higher acid medium.

Lack of nutrition affected all species alike, causing a general lack of luxuriance, lack of color in submerged mycelium, and absence of aerial mycelium. This reached the extreme on the leached agar, where the aerial mycelium was almost entirely lacking and the submerged mycelium colorless and not at all characteristic, with the exception of M. sarcinaeforme, noted above.

Some species were much more stable in characters than others. The species which showed least change in conidiophore and spore characters due to media were A. solani, A. tenuis, A. brassicae v. microspora, A. fasciculata, M. sarcinula, and M. sarcinaeforme. All of the others showed considerable variation on one or more of the media. Most variable were A. dianthi, A. sonchi, and A. brassicae v. nigrescens. (Tables 1-11).

Besides a general retardation of growth at the lower temperature and the general reduction of spore production, there were several features worthy of note. A. sonchi, produced normal sized spores at 10°, which it did not do at room temperature on any artificial medium. A. dianthi and M. sarcinaeforme, (Tables 7 & 10), at 10° produced spores much above normal dimensions, while A. brassicae v. microspora produced spores of normal length, but of half normal width. (Plate 1, A: No. 15.)

The comparative studies noted above were made with cultures which were ten days old, but all of the cultures were maintained thirty days or longer; sometimes ninety days. In some cases marked variations due to age were noted in the spores. In several species secondary growth or development of spores occurred which

entirely destroyed their distinctive characters. This secondary development consisted in a multiplication in the number as well as a great enlargement of the cells. This caused the spores to become very irregular in form, much darker, deeply constricted, and very much larger than normal. (Plate I, A: Nos. 2, 6, 10.)

As a result of the secondary development, the spores of Alternaria assumed the form of Mystrosporium, as was pointed out by Constantin.[14] Corda[21] in his description of the genus Mystrosporium made figures which are undoubtedly Alternaria spores in an advanced stage of secondary growth. Later[21] he figured the development of M. stemphylium from the regular form of a young Alternaria spore through the various stages of secondary development to the very irregular form called Mystrosporium. From the descriptions of species of Mystrosporium there is no doubt that most if not all belong to Alternaria in various stages of secondary enlargement.

Young colonies of all species of Alternaria produced smooth regular spores which remained regular for a time interval which varied in different species and on different media. The richer the medium the earlier the secondary enlargement began. The first indications of this secondary growth were multiplication of and deep constriction at the septa. On leached agar no secondary enlargement occurred in any species, even after a lapse of three or four months. There occurred irregularly in all species well marked echinulation of the spores. Beyond a deep constriction at the septa, no secondary change was noted in Macrosporium, nor A. sonchi, A. brassicae v. microspora, and A. solani from potato. This latter, however, produced spores in numbers sufficient for observation only on leached agar where secondary enlargement did not occur in any species.

V. DISCUSSION.

A general survey of the characters upon which specific descriptions of Alternaria and Macrosporium are, or may be based is fitting in this place.

Broadly considered, the different bases for descriptions may be divided into natural morphology, cultural morphology and media changes, and host relations. In the present studies effort was made to get a fair estimate of the value of each of these by studying them under various conditions.

In specific descriptions the shape, size, and color of spores are generally given. Also septation, constriction, and echinulation are more or less frequently mentioned. In many instances one of these characters may furnish the only point of differentiation of one species from another species in the description of which that character is not mentioned.

The conidiophores are generally more or less definitely described, the characters commonly given being, length, width, septation, constriction, color, branching and geniculation. As in the case of the spore characters, any one or all of these characters may be neglected by one author or made the basis for specific description by another.

The nature of the submerged mycelium has been made the basis for specific descriptions in some cases, although in many cases it is not mentioned. In artificial cultures where the mycelium is easily studied it is generally taken into consideration. The characters noted are thickness, length between septation, color, constriction, fasciculation and rate of growth.

Aerial mycelium is not often mentioned in specific descriptions. Length, width, color, abundance, and general habit are

the characters considered.

Morphology

1. The Spore.

The previously described experiments show that within the natural range, the size of the spores under natural conditions was in almost all of the species studied, quite constant, although when the inoculated plants were kept under bell jars there was much more rapid enlargement of the diseased spots and an increase in the amount of spore production. Under ordinary cultural conditions the size of the spore on artificial media is usually less than that on the natural host. However, in a relatively short time (two to six weeks). in some species there is a marked secondary development.

The characteristic thing about the spores of these fungi is their shape which is an immediate index to the genera, and generally to the species. All obclavate, cuneate, ovate, pointed or beaked spores belong to Alternaria and under suitable conditions form chains. There is more or less variation in shape within a single species, but in most cases under natural conditions the shape of the spore, combined with its size identifies the species. Parasites as they are collected during the period of active attack upon the plants, are uniform in spore form. Some species wintering on decaying leaves showed a secondary development which quite destroyed their characteristic form and size and made recognition impossible. On artificial media where secondary growth occurred frequently, the shape of the spores was greatly changed.

Macrosporium spores are globular, sarcinaeform or oblong in shape and usually rounded at both ends so that it is impossible when the spores are detached to tell which end is the base and which the apex. All Alternaria spores, however, have a more or less acute

apex and many species have beaks. In some cases the beaks are six or seven times the length of the spore itself. This, however, occurs only when they are not borne in chains, or in the terminal one of a chain. In the chains the terminal spore is formed by budding out of the apex, or occasionally from the side so that the spore above takes the place of the beak of the spore below. For this reason the length of beak alone can not be taken as of great value. Many species of Alternaria do not have beaked spores, so to a certain extent, the beak is a specific character.

There is marked difference between species in the number of septa. Septation is dependent on the size of the spore in a single species, but independent of the size of spore in different species. For example, a large spore of Alternaria iridicola may be the same size and shape as a spore of A. solani but the former has many cross and longitudinal septa while the latter has few cross septa and probably none longitudinally. The amount of septation increases with the age of the spore. The same conditions which brought about changes in shape and size of spores, increased the number of septa and constriction at the septa.

Echinulation occurred at times in all of the species studied. In some cases part of the spores from a colony were echinulate while others were smooth.

When the age of the spore is considered, color is an important character of some species. Generally spores darken with age. Macrosporium sarcinaeforme and M. sarcinula produced almost identical spots on red clover leaves. The difference in the color of the spores alone however, distinguish the two species since the mature spores of M. sarcinaeforme are very dark, and opaque, while those of M. sarcinula are not much darker than the young spores of

M. sarcinaeforme. Only three species showed variability in color of spores due to the cultural conditions. Alternaria dianthi and A. brassicae v. microspora, showed a marked change, both being very light amber instead of the normal dark olive. A. fasciculata, forming spots on partially etiolated cabbage leaves and also in growing on raw disinfected cabbage leaves and petioles showed a similar change.

2. Conidiophores.

The form of the conidiophore is often quite characteristic, although length depends upon the age and environment. In Macrosporium sarcinaeforme the end of the conidiophore becomes swollen before the spore appears. If this spore falls off another bud forms at the end of the conidiophore producing another "joint" which in turn swells at the end and produces a spore. If the spore does not fall off the conidiophore may bud again at the side of the swollen end and produce a second short "joint" which bears another spore. This process, repeated, causes the geniculation which is sometimes given as a specific character. In M. sarcinula, due to the fact that the ends of the conidiophores usually do not swell before producing spores, geniculation is less marked. Branching occurred occasionally in all the species but was not observed under natural conditions. The width of the conidiophores was quite constant. Constriction differs between species and with the age of the conidiophore. In some species no constriction was noted while in others the constriction was marked. The character is valuable only in a very general way.

Color is as distinctive of the conidiophores as of the spores and is usually concolorus with that of the spores. In some cases the conidiophores are lighter colored than the spores.

The only variations in the color of conidiophores on art-

ificial media corresponded with the color change of spores.

3. Aerial mycelium.

Parasitic species under usual conditions produce little or no aerial mycelium. Under very humid conditions, a ver y little aerial mycelium was sometimes produced by some species. This was always lax and white, and altho in some species it was thicker in cross section than in others, it was so nearly featureless as to be thought worthless in classification. More or less aerial mycelium was produced by all species under some conditions of artificial culture. In some species, notably A. brassicae v. microspora, and M. sarcinaeforme, it could be found only with the microscope. Other species produced aerial mycelium in abundance under humid conditions, on rich media.

4. Submerged mycelium.

The characters of the submerged mycelium were the most variable of all characters studied. Under ordinary culture conditions on standard media the mycelium of some species had distinguishing characteristics, but any change in the cultural conditions might bring about a change in the characters of the mycelium which would make its identity doubtful. On low grade nutrient agar the mycelium of most species was colorless and, with a few exceptions, characterless. On some media the color, width and general character might separate certain species from certain other species, but under the influence of strong inhibition, such as was brought about by bacterial influence, the changes entirely destroyed any distinguishing characters. In most cases age greatly affected the mycelium in color, septation, and construction.

Host Relation.

Inoculations upon host plants show that some species are

quite narrow in their range; e.g. A. sonchi was parasitic on Sonchus asper and Lactuca canadensis but failed to maintain itself on cultivated lettuce and other Compositae. Others may be broader in their range, growing actively on many species of one family and less actively on other families; as, A. solani which grew actively on all Solanaceous hosts tried and less actively on cabbage. A. brassicae v. microspora grew actively on all Cruciferous hosts inoculated but failed in all inoculations outside of that family.

Forms morphologically inseparable may grow on different hosts and fail to cross inoculate, or of several forms morphologically alike only one may be parasitic, as in the case of A. dianthi which is morphogically inseparable from A. tenuis. On the other hand, forms which are morphologically clearly distinct may be equally parasitic on the same host as are; A. brassicae and A. brassicae v. microspora.

VI. GENERAL CONSIDERATIONS

The studies just presented were made with the view of determining a basis for the differentiation and limitation of the two genera studied, and also of their species.

The present prevailing custom of describing species on several different grounds, such as host relations, small variations of obscure or very unstable morphological characters, i.e. cultural characters, has placed the subject in a very unsatisfactory state. In some genera it is hopeless to attempt to identify species from the descriptions given. Phyllosticta, Phoma, and Septoria are all too familiar examples of this condition.

An example of the confusion wrought by the different usages of mycologists is well illustrated in the genus Alternaria. In the

"Sylloge Fungorum" seven varieties of Alternaria brassicae are described. Six of these varieties are evidently described upon the grounds of their similarity to and variations from A. brassicae, while the seventh variety, A. brassicae v. microspora, since it has not the slightest morphological resemblance to A. brassicae, is doubtless described as a variety on the basis of host relations. If such distinctly different forms as A. brassicae, A. brassicae v. nigrescens, and A. brassicae v. microspora are to be included under a single species, there is not a form of Alternaria but might upon morphological grounds properly be placed under this one species. Such a procedure is clearly unreasonable and destroys the concept of a species. On the other hand, Planchon[14] in working with two strains of Alternaria which under ordinary conditions were similar, describes them as two new species (A. variens and A. polymorpha) on account of variations in their reactions to chemical media. Such a ground for the basis of specific names also destroys the value of the conception of a species.

The present studies of Alternaria and Macrosporium have shown that under natural conditions or under ordinary cultural conditions, the morphological features of a species by which it can be identified, i.e. the spores and conidiophores, are quite constant. On the other hand, the present studies and previous work by others [14-15] have shown that marked variations may occur in many species due to the media used. But as has been pointed out by Thom,[16] "It is manifestly impracticable to repeat a long series of variation experiments with a number of different fungi simply as a means of identification of a form sought". He further states, in agreement with other writers, that in the genera of fungi which show great variation, the hope for a stable identification is in culture for

several generations under rigorously uniform conditions. That such work as that of Planchon (l.c.) is valuable in showing the variations which culture on various media is able to produce, is conceded; but that such variation should be used as a basis for describing new species is at best inadvisable.

Host relation is a basis for specific descriptions is sure to lead to absurdities in many cases, and gives no indication of the morphological affinity of different species or of the varieties of a species, as in the case of A. brassicae cited above.

Since we must discard host relations as a basis for specific distinction, unless we are ready to adopt bacteriological methods for the identification of fungi, (and these would be applicable only to such species as would grow saprophytically), there seems to be no reasonable or workable ground for the description of species in the genera in question, other than that of the morphology of the spores and conidiophores under normal conditions.

VII. GENERIC LIMITATIONS OF ALTERNARIA AND MACROSPORIUM.

Alternaria

In every case where species of Alternaria have been described, the spores have been more or less elongated and pointed at one end. In the present studies all spores of the obclavate, cuneate, or ovate form produced chains of spores under favorable conditions. Since the species studied in culture covered all the types of spores found in exsiccati or described in the "Sylloge Fungorum" under the genera Alternaria and Macrosporium, there is no doubt that all of the species with these types of spores belong to the genus Alternaria, that most of the species named under Macrosporium belong to this genus and can be recognized as such by the descriptions

given of their spores.

The term "clavate" as applied to the Alternaria spores is a misnomer arising from a misconception and carrying misconception with it. Without exception the pointed end of the spore is the apex and the rounded end is the base. Berlese figures Alternaria tenuis spores attached by their apices, and as this error was widely copied it undoubtedly went far toward spreading the misconception. Other authors have figured spores of other species of Alternaria, (described as Macrosporium), attached by their beaks, and it is a common conception that the beak is a pedicel. Many authors have made correct descriptions and figures of Alternaria spores in describing them either as Macrosporium or Alternaria. In such cases the term "obclavate" replaces "clavate".

The generic description of Alternaria* should be emended as follows:

ALTERNARIA Nees. Conidiophores solitary or fasciculate, erect or subdecumbent, simple or branched, generally short, colored. Conidia muriform, often with few longitudinal septa, ovate, obclavate, or elongate, always with more or less definitely pointed apex, often long beaked, colored; under favorable conditions forming chains. (Ex. A. tenuis, the type of the genus.)

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*ALTERNARIA Nees Syst. d. Pilze 11, p. 72 (Etym. alternus ob conidia alterne crassiora et tenuata) - Hyphae fasciculatae, erectiusculae, subsimplices, breves. Conidia clavato-lageniformia septato-muriformia per isthmos (conidiorum caudas) catenulatim digesta, mox vero secedentia. - Polydesmi, Macrosporii et Clasterosporii species nonnullae obiter observatae forte huc spectant. (Saccardo, Sylloge Fungorum 4: p. 545.)

Macrosporium.

Of the four species of Macrosporium described by Fries when he created the genus, M. convallariae and M. cheiranthi undoubtedly belonged to Alternaria. Fries, however, had rejected the genus Alternaria and placed A. tenuis in the genus Torula as T. alternata. In the exsiccati studied, specimens labeled as M. convallariae and M. cheiranthi belong to Alternaria. The third species of Fries, M. tenuissimum, (Helminthosporium tenuissimum Nees), is placed by Saccardo in the genus Clasterosporium as C. tenuissimum. The fourth species of Fries original publication, M. caricinum, is not mentioned by Saccardo. The material for this species was supplied to Fries[17] by Schweinitz and the description of Fries corresponds exactly with the description and figures of Schweinitz[19] for Clasterosporium caricinum which is the type of the genus Clasterosporium. There is no doubt, therefore that the types of Clasterosporium caricinum and Macrosporium caricinum are from the same material.

Corda[21] placed Clasterosporium caricinum in the genus Sporodesmium as S. closteriosporium but the genus Sporodesmium was at that time so heterogeneous that such a disposition cannot be considered final.

Since Macrosporium caricinum Fries and M. tenuissimum (Nees) Fries, were published two years before Clasterosporium caricinum Schw., M. tenuissimum (Nees) Fries becomes the type of the genus Macrosporium, which will take over the species now given under the genus Clasterosporium, Clasterosporium, being antedated by Macrosporium.

All but twenty of the species of Macrosporium listed in the "Sylloge Fungorum" certainly belong to Alternaria. These twenty are given as having globular and sarcinula; or globular and clavate

spores. The latter species may possibly have both forms of spores but it is much more probable that the "clavate" spores belong to Alternaria and that two distinct species were present when the species were described. Such mixtures were found in the exsiccati in several instances.

All of the twenty species given in the "Sylloge Fungorum" having sarcinula or globose spores are one species in so far as spore measurements are dependable. Of the thirteen specimens found in exsiccati, however, there were two distinct forms, and two distinct forms were cultured during the present studies. Some of the names of the twenty species in question have already been reduced to synonymy and it is probable that only a few distinct forms exist.

There is nothing in the morphology of the species of this group which would exclude them from the genus Stemphylium.

The species now named Macrosporium which should be put into Stemphylium providing they are distinct species, are: M. sarcinula Berk, M. sarcinaeforme Cav., M. abruptum, C. & E., M. baccatum Ell. & Kell., M. valerianellae Roum., M. elegantissimum Rabh., M. pelargonii E & E., M. globuliferum Westergr., M. toruloides, E. & E., M. nodipes Sacc., M. schewnitziense Baumel., M. puccinioides E. & A., M. chartarum Pk., M. myrmecophilium (Fries) Sacc., M. nitens (Fries) Sacc. M. subglosum, Cke. & Rav., M. rosarium Penz., M. septosporum Rabh., M. atrichum C. & E., M. parasiticum Thum., M. commune Rabh., as figured by Saccardo also belongs in Stemphylium; but as described by Rabenhorst it is a mixture of Alternaria and Stemphylium.

VIII. SPECIFIC LIMITATIONS OF ALTERNARIA

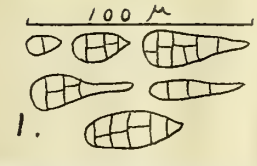
Except for the species named above as belonging to Stemphylium, all the species of Macrosporium of the "Sylloge Fungorum" belong to Alternaria and can be recognized as Alternaria from their descriptions.

In the present studies enough variation due to age alone, occurred in Alternaria tenuis, A. fasciculata, and A. dianthi, to fit these to a large percentage of the species of Alternaria and Macrosporium described in the "Sylloge Fungorum" and found in the exsiccati. No variations occurred in the forms in group 6, page 8, except those which would occur due to age, and all in this group might be considered A. tenuis and varieties of A. tenuis. Even the narrowest limitation in the application of specific names would preclude the retention of many of the present species.

No final disposition of the present specific names of Alternaria and Macrosporium can be made without a study of authentic specimens of each species. Most of the descriptions are far from being complete or definite enough to permit their being used for this purpose. For convenience a tentative grouping of similar forms which may be identical and which are undoubtedly closely allied, should be made. These groups might well be retained to indicate the similarity of a number of forms such as is exemplified in bacteriology in the B. coli and B. subtilis groups. As in bacteriology each group should be designated by a typical species.

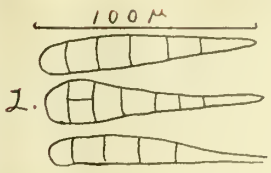
The groups suggested are as follows:

The A. tenuis group. This group is characterized by spores ranging from 15-50 x 7 - 20 mu. The spores are quite variable in form as well as size but are generally broad and muriform.



Spores of the A. tenuis group

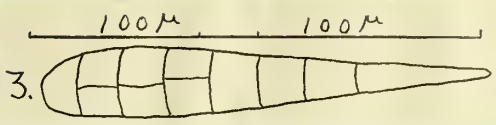
(Text fig. 1.) All specimens mentioned in group 6, page 8, belong here.



Spores of the A. brassicae group

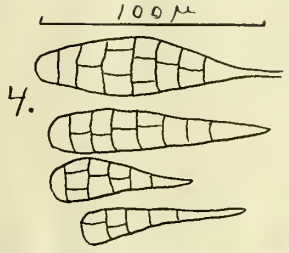
The A. brassicae group. This group should contain A. brassicae, A. solani, and other regular, long, tapering, acute-beaked spore forms with measurements ranging from 35-120 x 10-30 mu. The spores have few longitudinal septa and are often long beaked. (Text fig. 2) All of group 3, page 7, belong in this group.

The A. herculea group. A. herculea (E. & M.) com.nov. (Macrosporium herculeum E. & M.) is the type of a group with spores similar in form to those in the A. brassicae group (Text fig. 3.) but much larger. To this belong the specimens mentioned in group 4, page 8.



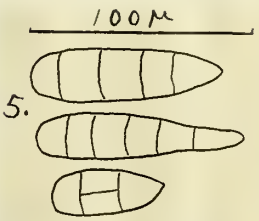
Spore typical of the A. herculea group

The A. cucumerina group. A. cucumerina (E. & E.) com. nov. (Macrosporium cucumerinum (E. & E.)syn. Alternaria brassicae v. nigrescens Peglion, is typical of a group similar in spore form to that of A. brassicae but with the spores uniformly wider and more muriform (Text fig. 4.) In size also they are about the same as A. brassicae but generally shorter. In this group should be placed all of group 5, page 8.



Spores of the A. cucumerina group

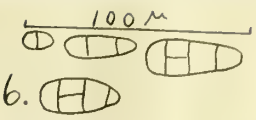
The A. sonchi group. A.sonchi Davis (in lit.) is different from any species in the above groups in having large-celled spores with a markedly obtuse apex. (Text fig. 5.). The range in size is from 50-125 x 12-25 mu. No sim-



Spores of the A. sonchi group

ilar form was found in exsiccati.

The A. microspora group. A. microspora (Sacc.) com. nov. (A. brassicae v. microspora (Berk.) Sacc. differs from A. tenuis in being uniformly narrower and less muriform; longitudinal septa seldom being formed. (Text fig. 6.) Here belong those of group 7, page 10.



Spore of A. microspora group

A more complete study of exsiccati might show the necessity of other groups for forms not included above.

Without doubt, the number of valid species of Alternaria is a very small percentage of the present named species of Alternaria and Macrosporium but it is outside the limits of the present paper to reduce these names to synonymy.

IX. SUMMARY

1. Spore shape in the genus Alternaria is correlated with catenulation of spores.

2. All obclavate, ovate, cuneate, or elongate pointed spores form chains and belong to Alternaria.

3. The acute end of the spore is the apex or beak, not the base or pedicel.

4. All globular, sarcinula, cubed, or oblong spores without apex or beak belong to Stemphylium.

5. Macrosporium, by priority, becomes the name of the genus which has been known as Clasterosporium Schw.

6. Of the four species described by Fries when he created the genus Macrosporium, two belonged to Alternaria and M. tenuissimum (Nees) Fries becomes the type of the genus Macrosporium.

7. Conidiophores and conidia possess the only suitable

characters upon which to describe species.

8. Conidia in many species go through secondary changes which destroy their distinctive characters.

9. Secondary changes in conidia may be due to age or to abnormal environment.

10. The genus Mystrosporium was described from Alternaria in advanced secondary development.

11. Mycelial characters are too easily effected by external conditions to be dependable in describing species.

12. Slight changes in media may cause great changes in the submerged mycelium.

13. Identical changes of environment may bring about opposite reactions in different species.

14. Morphology of the dependable stable characters under normal conditions is the most useful basis for describing species.

15. Due consideration must always be taken of age of the organism in describing a species.

16. For convenience, the genus Alternaria is divided into groups of species having similar spores.

PLATE I.

All drawings were made with camera lucida to scale shown on the plates.

A.

1. Alternaria brassicae v. nigrescens on leached agar.

2. Alternaria brassicae v. nigrescens spores showing stages in secondary development.

3. A. solani from Datura on leached agar.

4. A. solani from Datura, spores from bean agar culture.

5. A. solani from potato on leached agar.

6. A. tenuis spores two weeks and six weeks old showing secondary development due to age.

7. A.tenuis on leached agar.

8. A. dianthi on leached agar.

9. A. dianthi spores from colony on acid agar.

10. A. dianthi spores from colony on bean agar at 10^{o}, showing enlarged size and secondary development.

11. A. fasciculata on leached agar.

12. A. fasciculata spores showing echinulation.

13. A. fasciculata, showing development of a spore.

14. A. brassicae v. microspora on leached agar.

15. A. brassicae v. microspora on bean agar 10^{o}, showing reduced size of spores and lack of color.

16. Macrosporium sarcinaeforme on leached agar.

17. M. sarcinula on leached agar.

B.

1. Mycelium of A. solani from potato; a, reaction to bacterial influence; b, normal.

2. Mycelium of A. brassicae v. microspora; a and b as in No. 1.

3. Mycelium of A. brassicae v. nigrescens; a and b as in No. 1.

4. Mycelium of A. solani from Datura; a and b as in No. 1

5. Mycelium of A. tenuis; a and b as in No. 1.

6. Colony of A. brassicae v. microspora showing reaction to Colony of B. x.

7. A. iridocola on leached agar.

8. A. sonchi conidiophores and spores on Lactuca canadensis.

9. A. sonchi conidiophores and spores on leached agar.

10. Spores of A. solani from Datura; A, from Datura leaf spot; B, from potato leaf spot; C, from tomato leaf spot. (artificial inoculations.)

PLATE I

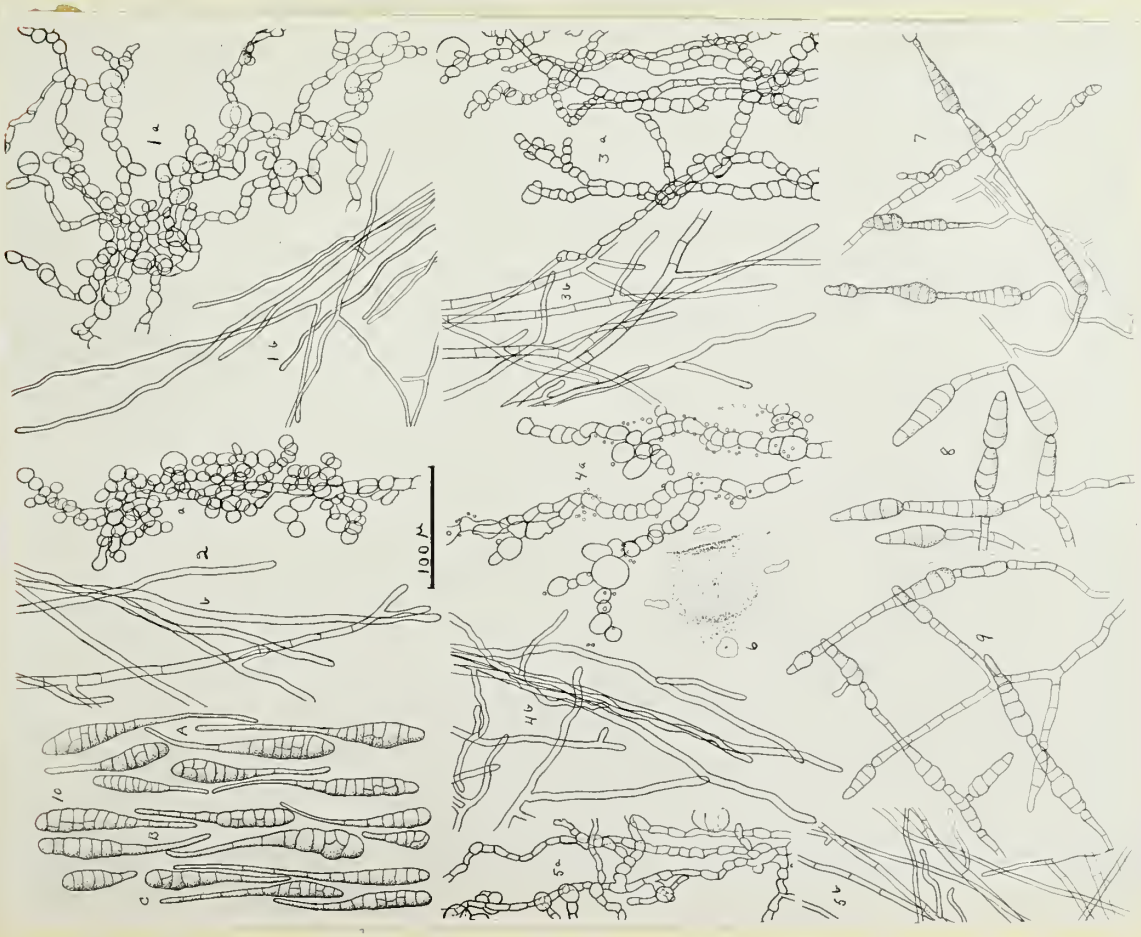


PLATE II.

All photographs are natural size.

1. Colonies of A. solani from potato; 10 days, 30°.

2. Colony of A. solani from potato; 30 days, 10°.

3. Colonies of A. solani from Datura; 10 days, 30°.

4. Colony of A. solani from Datura; 30 days, 10°.

5. Colony of A. brassicae v. nigrescens; 10 days, 30°.

6. Colony of A. brassicae v. nigrescens; 10 days, 30°.

7. Colony of A. brassicae v. microspora; 10 days, 30°.

8. Colony of A. brassicae v. microspora; 30 days, 10°.

9. Colony of A. brassicae v. microspora; 30 days at 10°, then for 2 days at 30°, and 7 days at 10°; showing ring of dark spores produced at the higher temperature. Same colony as figure 8.

10. Colony of A. brassicae v. nigrescens showing reaction to influence of colony of B. x.

11. Colony of A. fasciculata; 10 days, 30°.

12. Colony of A. fasciculata; 30 days, 10°.

13. Colony of A. tenuis; 10 days, 30°.

14. Colony of A. tenuis; 30 days, 10°.

15. Colony of A. dianthi; 10 days, 30°.

16. Colony of A. dianthi; 30 days, 10°.

PLATE II

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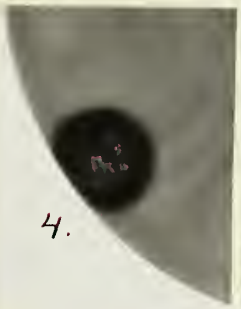
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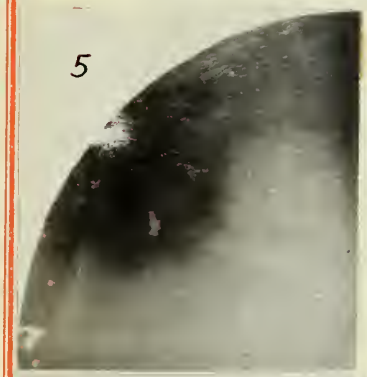
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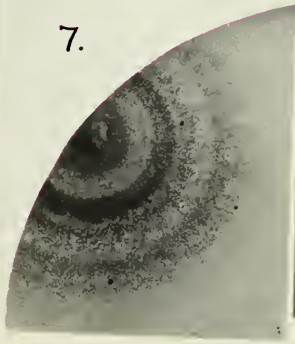
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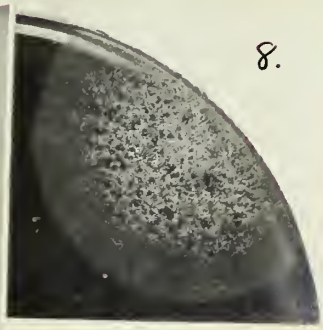
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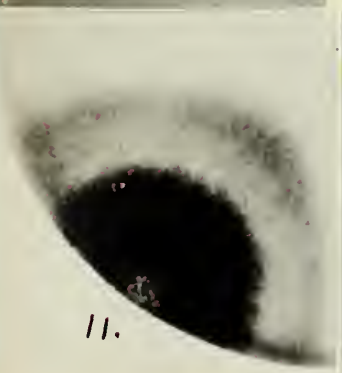
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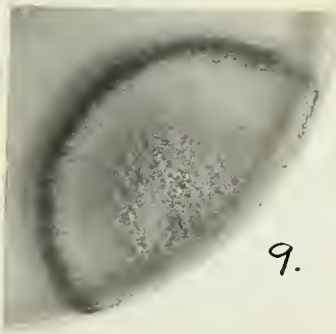
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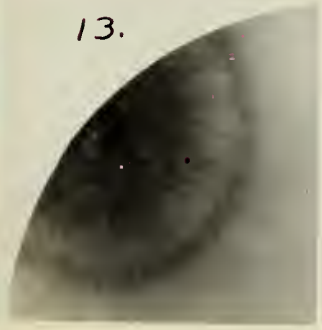
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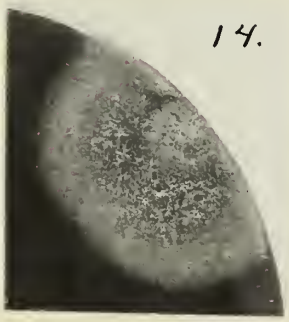
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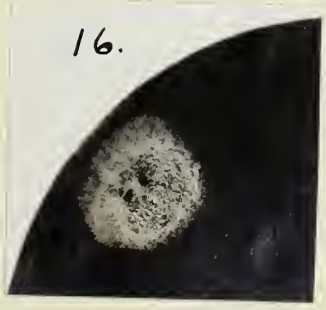
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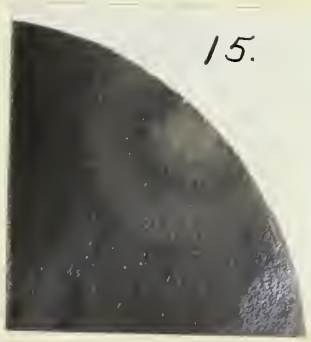
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PLATE III.

1. Colony of A. iridicola; 10 days, 30°.

2. Colony of A. iridicola; 30 days, 10°.

3. Colony of A. sonchi; 10 days, 20°.

4. Colony of A. sonchi; 30 days, 10°.

5. Colony of M. sarcinaeforme; 10 days, 30°.

6. Colony of M. sarcinaeforme; 30 days, 10°.

7. Colony of M. sarcinula; 10 days, 30°.

8. Colony of M. sarcinula; 30 days, 10°.

9. Normal mycelium of A. solani from potato, on bean agar.

10. Mycelium of A. solani from potato, showing reaction to bacterial influence.

11. Normal mycelium of A. solani from Datura on bean agar. (9, 10, 11, magnified 150 diameters.)

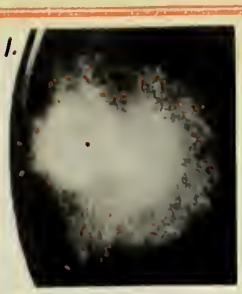
12. Spots caused by M. sarcinula on red clover and alfalfa leaves.

13. Spots caused by M. sarcinaeforme on red clover, alfalfa and white clover leaves.

14. Spots caused by A. solani from potato on cabbage leaf.

15. A. fasciculata on etiolated and wilted tomato leaves.

PLATE III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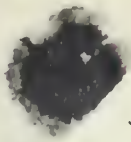
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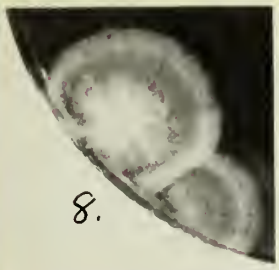
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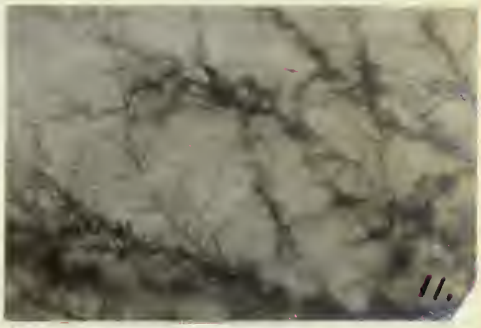
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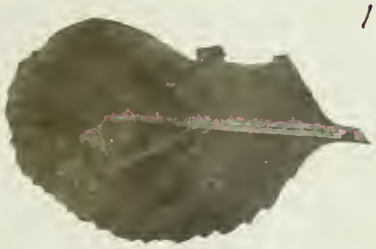

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PLATE IV.

1. & 2. Spots on leaves of tomato and Datura caused by A. solani from Datura.

3. Spot on partially etiolated cabbage leaf caused by A. fasciculata.

4. & 5. Spots on leaves of Datura and Solanum nigrum caused by A. solani from Datura.

6, 7, & 8. Spots on leaves of Solanum nigrum, potato, and Datura caused by A. solani from potato.

9. & 10. Spots on leaves of cabbage and radish caused by A. brassicae v. microspora.

11. Spots on leaves of Lactuca canadensis caused by A. sonchi.

PLATE IV

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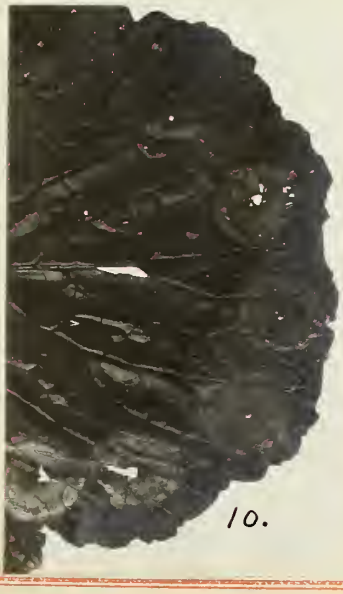
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PLATE V.

1. & 2. Spots on leaves of tomato and potato caused by A. solani from potato.

3. & 4. Spots on leaves of tomato and potato caused by A. solani from Datura.

5. Dianthus leaf inoculated with A. tenuis, (no spots.)

6. Leaf of day lily inoculated with A. iridicola (no spots)

7. & 8. Spots on leaves of iris caused by A. iridicola.

9. & 10. Spots on leaves of onion caused by A. iridicola.

11. Spots on leaf of onion caused by M. sarcinaeforme.

12. & 13. Spots on leaves of onion caused by M. sarcinula.

14. Onion leaf with sterile punctures used as check.

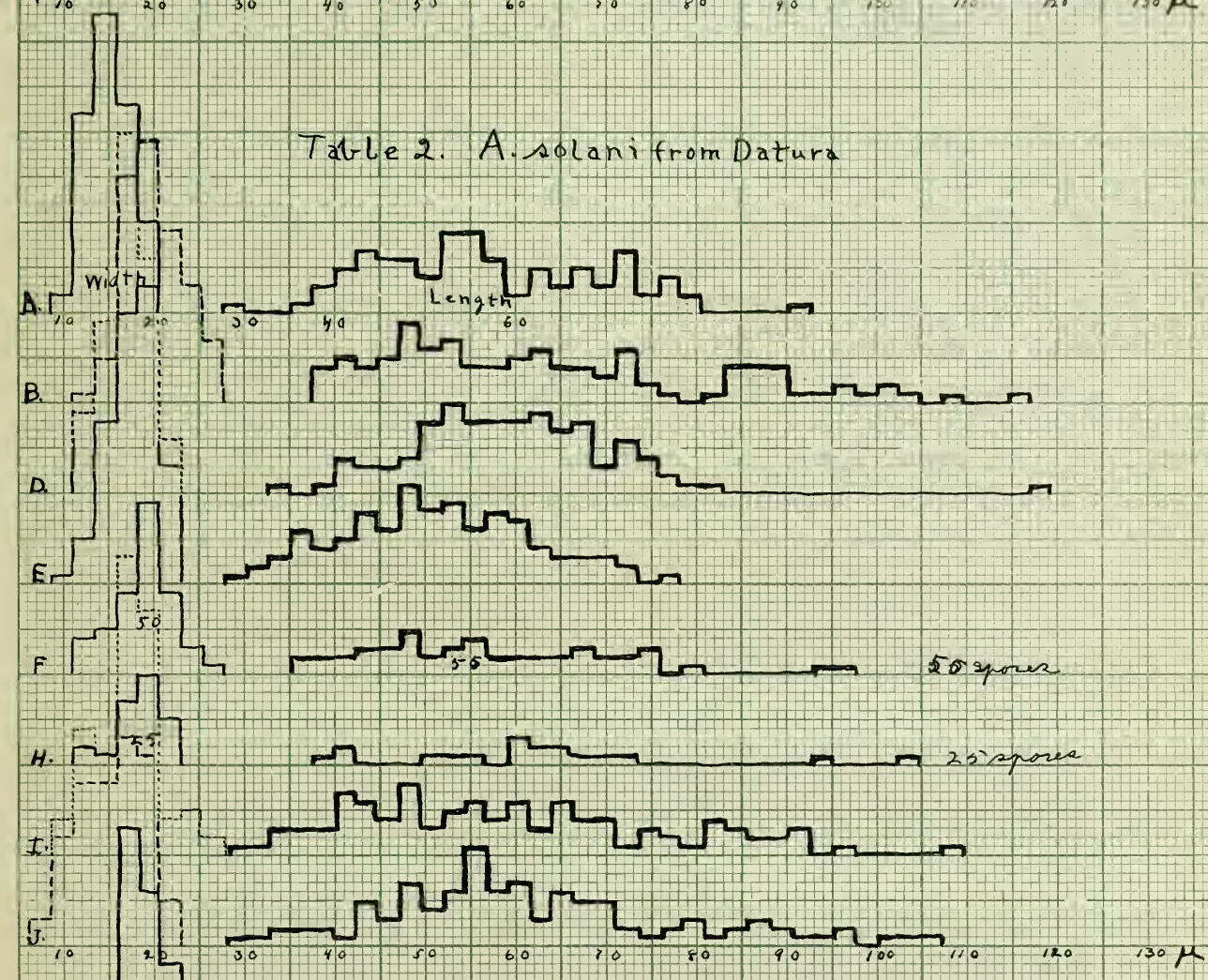
PLATE V

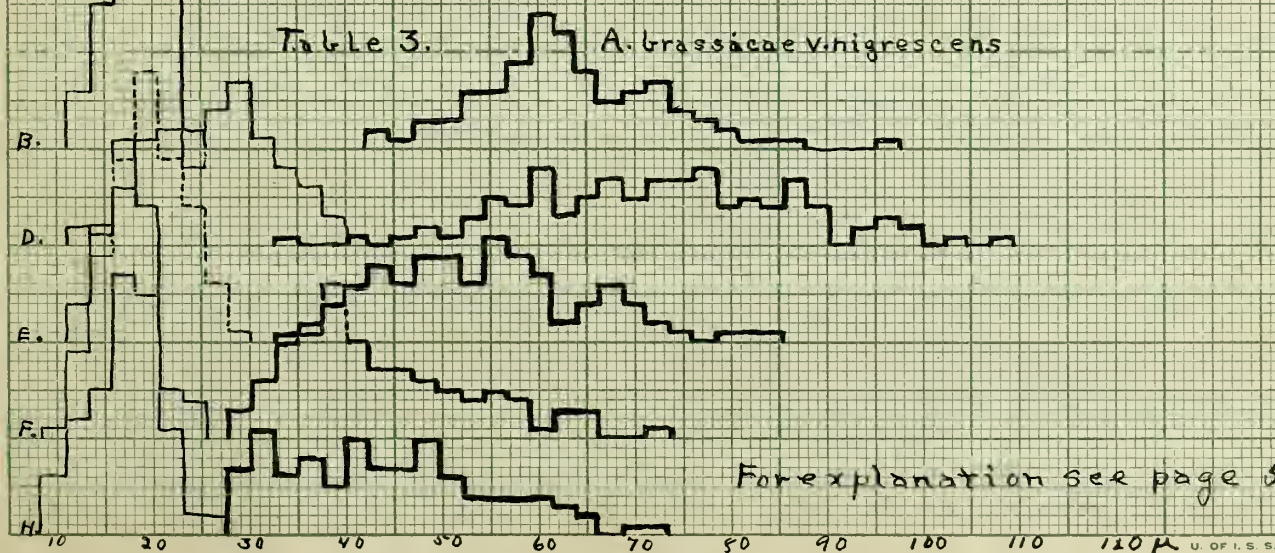
Explanation of Tables 1 to 11.

The measurements of spores are indicated in microns by the base line, each space representing one mu. The frequency is indicated on the perpendicular lines, each space representing one spore. Measurements are at intervals of 2.4 mu except in the narrower spores where the width is taken at intervals of 1.2 mu.

The following letters are used to indicate the host and media: A, natural host; B, bean agar, 30°; C, bean agar, 10°; D, bean agar, + 20 Fuller's scale; E, bean agar, - 20 Fuller's scale; F, synthetic agar; G, synthetic agar minus glucose; H, synthetic agar with double amount of glucose; I, synthetic agar with double amount of asparagin; J, synthetic agar without asparagin; K, leached agar..

The most striking facts to be observed are: General reduction in size of spores on the synthetic agars, (F to J), over bean agars, (B. to E). Relative constancy of species given in tables 2, 4, 5, 6, 10, 11; over those given in tables 3, 7, 8, and 9. Increase in size of spores at lower temperature, (tables 7, 9, 10: C.). Extreme range of variation in size of larger spores, (tables 1, 2, 3, 8 and 9).





For explanation see page 58.

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Table 4. A. brassicae v. microspora

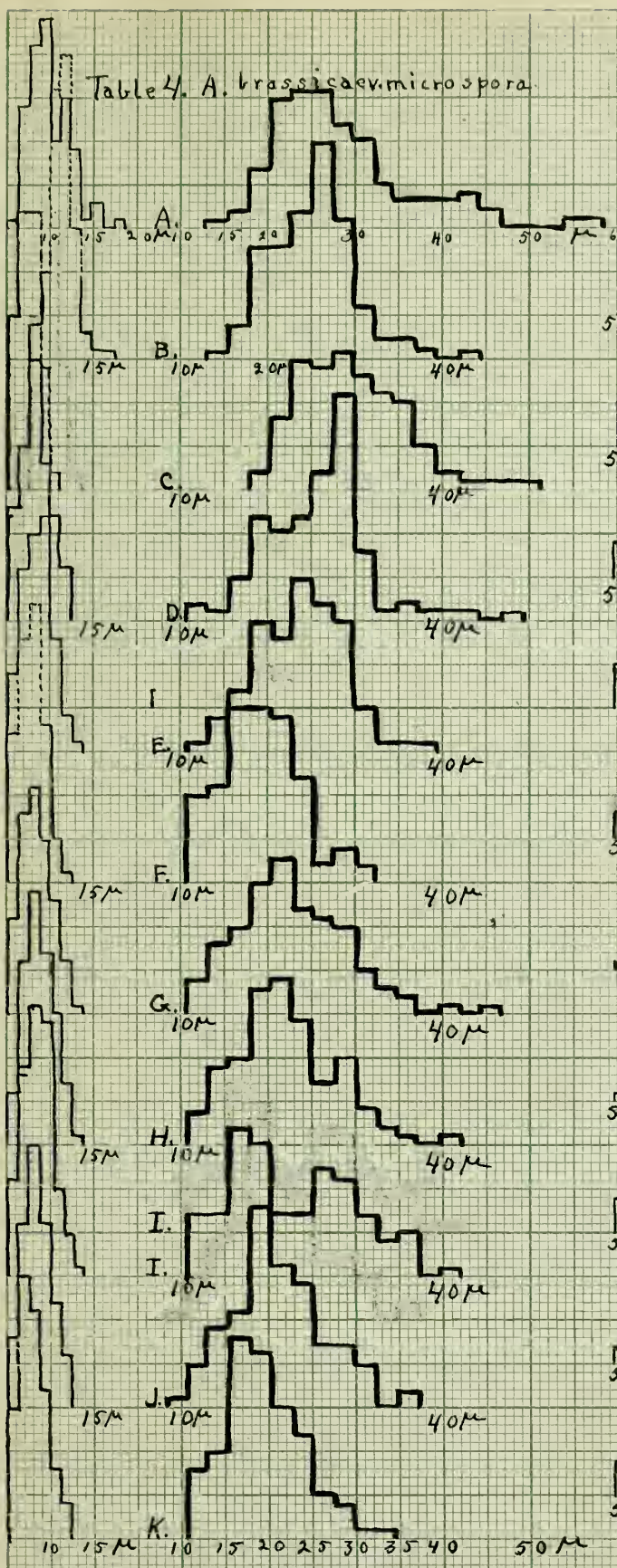
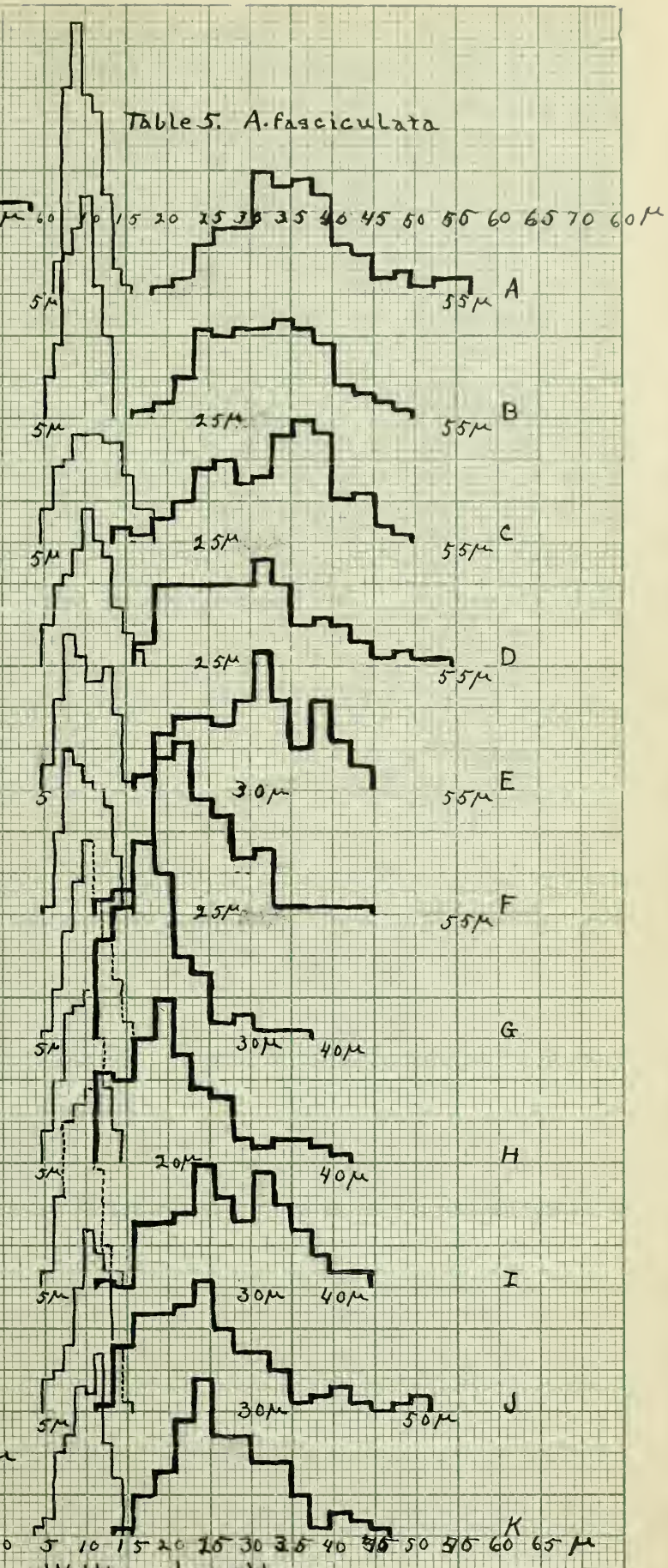
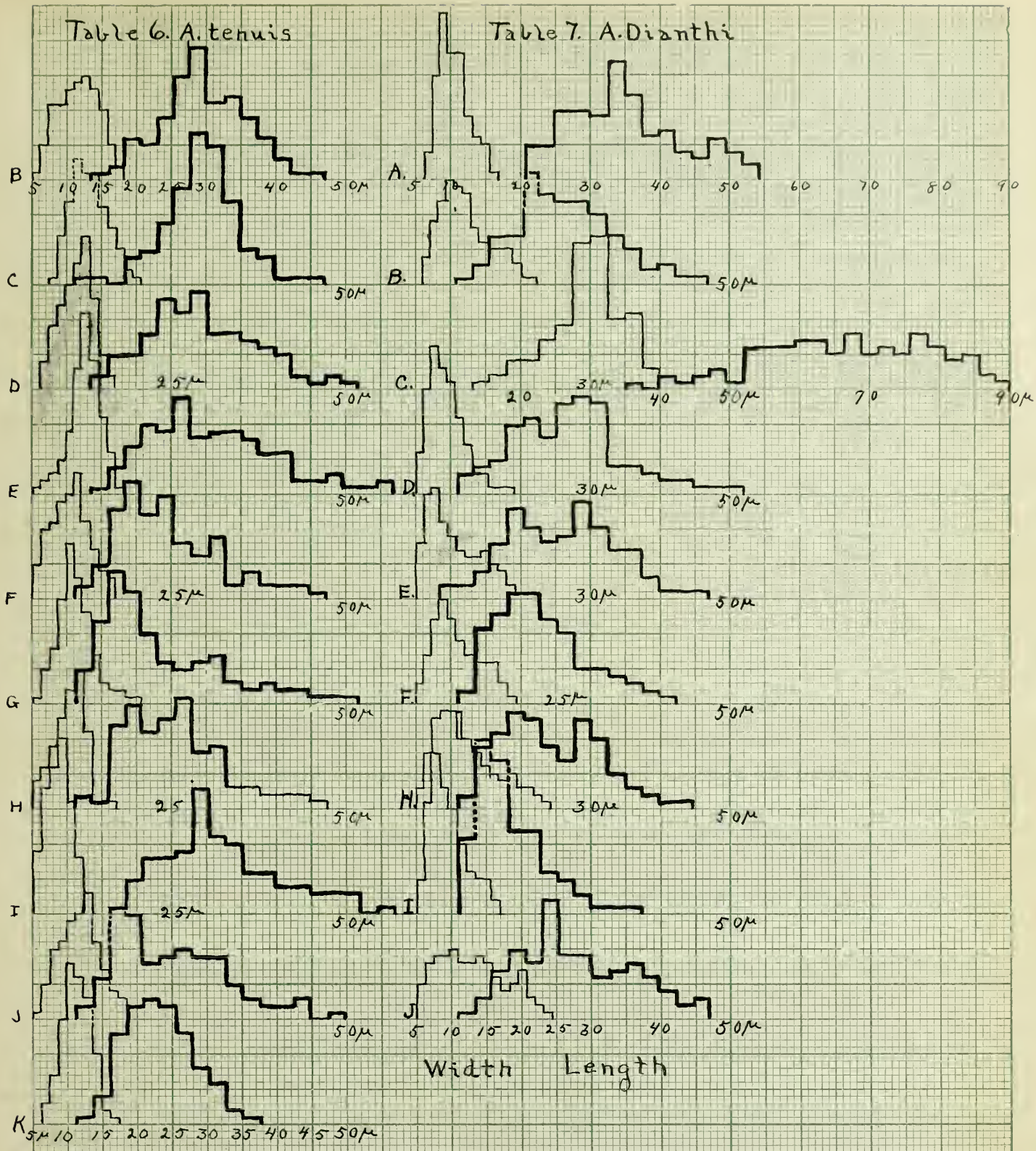


Table 5. A. fasciculata



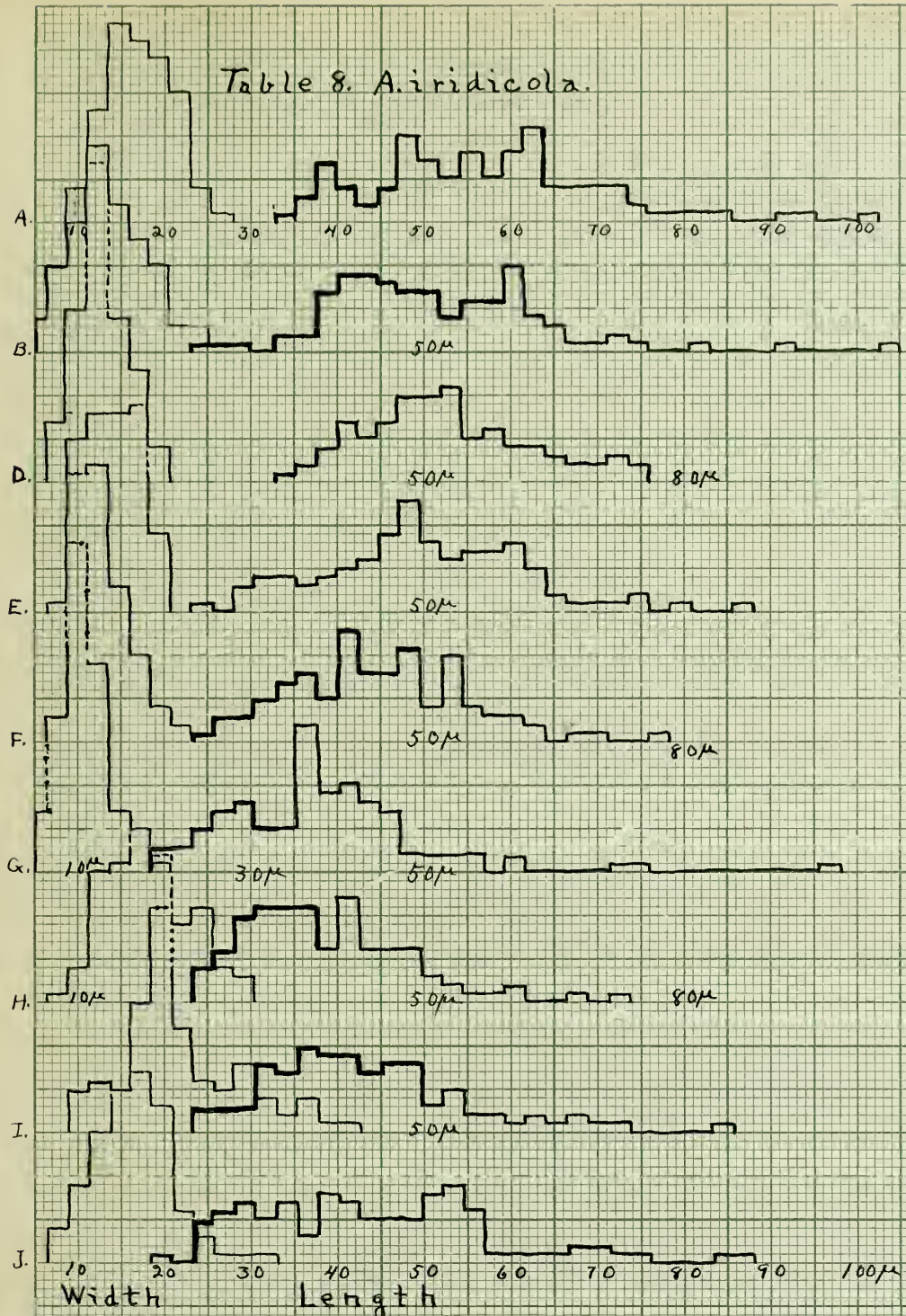
For explanation see page. 58.

U. OF I. S. S. FORM 3



For explanation see page 58

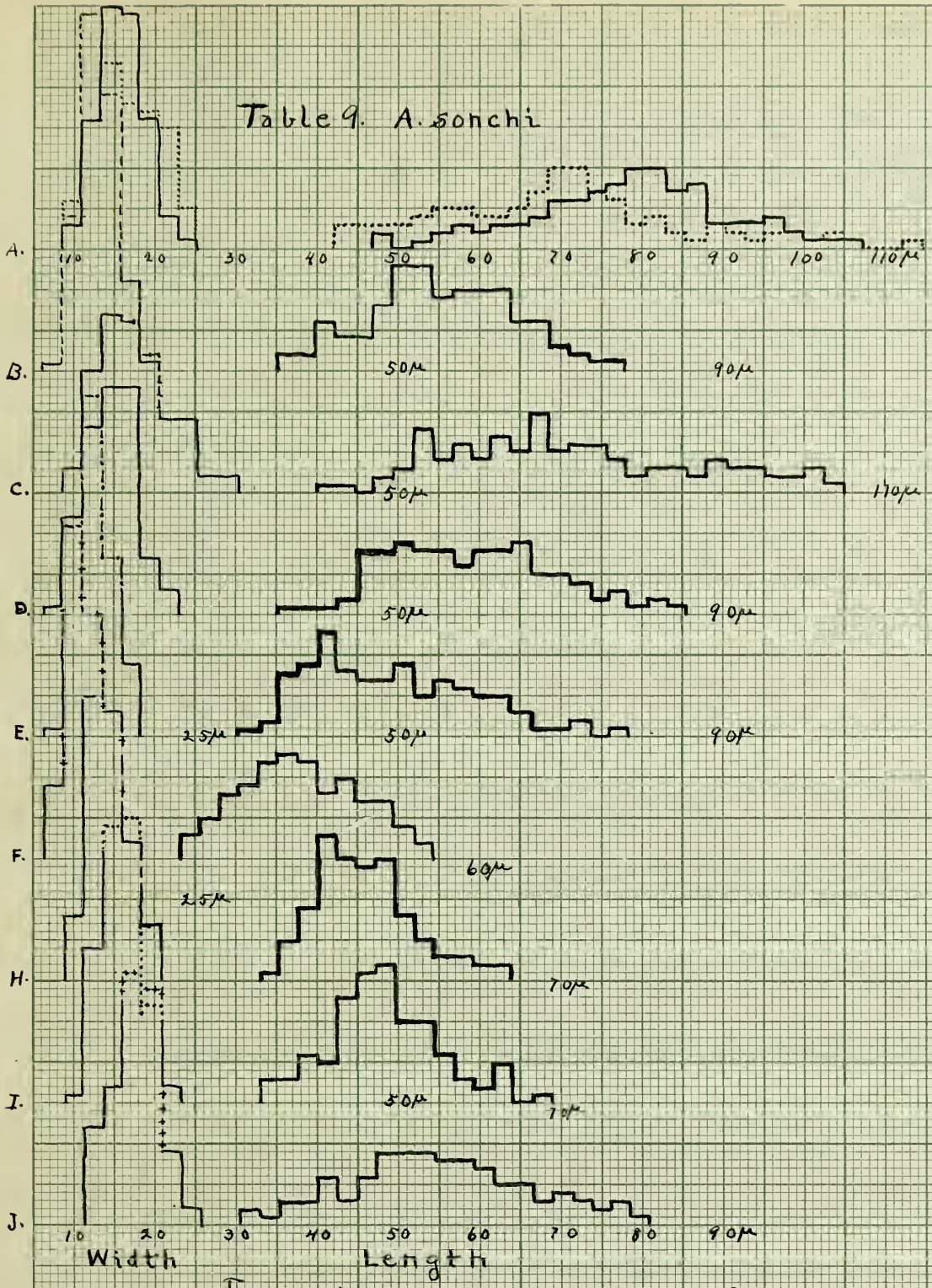
U. OF I. S. S. FORM 3



For explanation see page 58.

U. OF I. S. S. FORM 3

Table 9. A. sonchi



For explanation see page 58.

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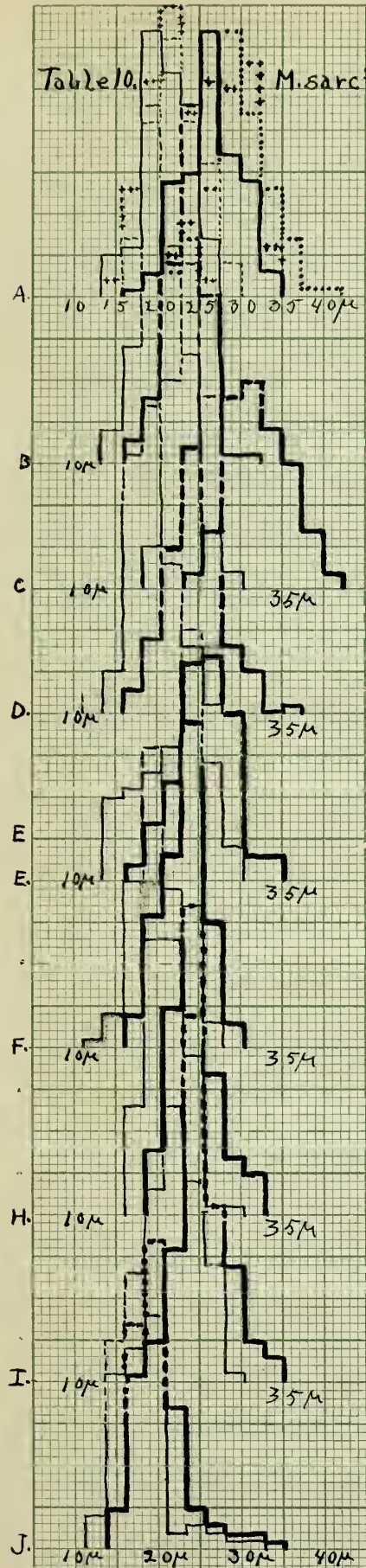
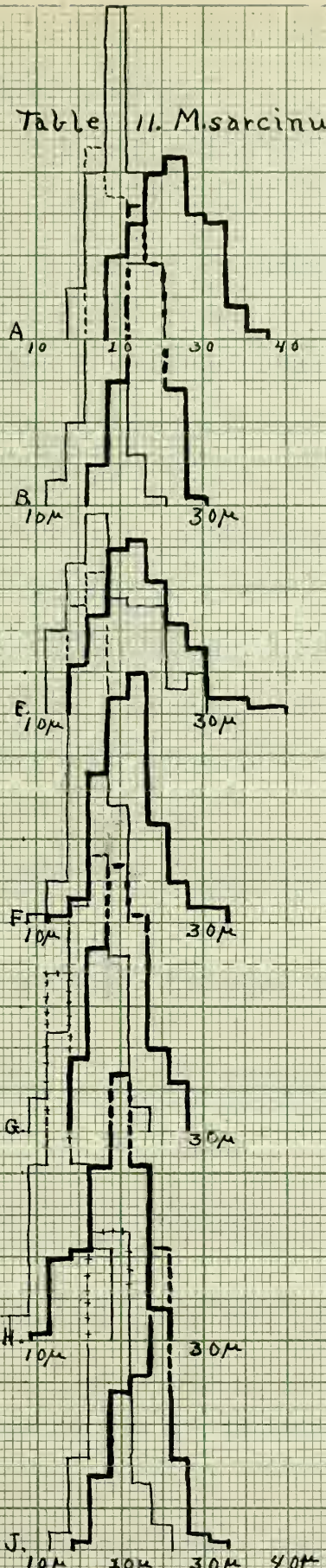
Table 10. M. sarcinaeforme



Width - narrow lines
Length - wide "

Table 11. M. sarcinula



Width - narrow lines
Length - wide "

For explanation see page 58.

U. OF I. S. S. FORM 3

X. BIBLIOGRAPHY

1. Tulasne, L. R. et C., Selecta Fungorum Carpologia, Tom II: 261. Plate 32: figs. 1-14, Plate 33: figs. 11-14. (Figures both Alternaria and Macrosporium conidia with Pleospora herbarum.)

2. Gibelli, G., e Griffini, L., Sul polimorfismo della Pleospora herbarum Tul., in Archivio Triennale del laboratorio di botania crittogeniea in Pavia. Vol. 1: 53-102, tav. V-IX. 1874 (Taxonomic.)

3. Mattirolo, O., Sul polimorfismo della Pleospora herbarum Tul. e sul valore specifico della P. sarcinula e della P. alternariae di Gibelli e Griffini. Malpighia 2: 357. 1888. (Taxonomic.)

4. Bauk, H., Zur Entwickelungsgeschichte der Ascomyceten. (Pleospora herbarum.) Bot. Zeit. 1877: 313-326. (Life history.)

5. Kohl, F. G., Uber den Polymorphiamus von Pleospora herbarum. Bot. Cent. 18: 23. 1883. (Life history.)

6. Miyake, G., Life History of Macrosporium parasiticum. Ann. Bot. 3: 1. 1889.

7. Halsted, B. D., N. J. Rept. 13: 290. 1892. (Life history of Pleospora tropaeoli.)

8. Jones, L. R., Studies on Macrosporium solani. Vt. Rept. 9: 79. 1895. (Cultural.)

9. Jones, L. R., On Alternaria solani. Vt. Rept. 10: 45. 1896. (Important bibliography.)

10. Bioletti, F. T., Some diseases of olives. Calif. Rept. 1895: 243. (Cultural.)

11. Atkinson, G. F., Black Rust of Cotton. Bot. Gaz. 16: 62. 1891. (Cultural .)

12. Prillieux et Delacroix, Bul. Soc. Myc. France 9: 201. 1893. (Taxonomic.)

13. Constantin, M. J., Sur les Variations des Alternaria et des Cladosporium. Rev. Gen. Bot. 1: 453-466. 1889. (Cultural)

14. Planchon, L., Influence de Divers Milieux Chimiques sur Quelques Champignons du Groupe des Dematiees. Ann. Sci. Nat. Bot. 8: ser.II p.p. 1-248. 1900 (Cultural)

15. Berkeley, M. J., Notices of British Fungi. Ann. Nat. Hist. 1: 261. 1838. (Descriptive.)

16. Thom, C., Suggestions from the Study of Dairy Fungi. Jour. Myc. 11: 117-124, 1905. (Cultural.)

17. Fries, E., Syst. Myc. III: 373-375. (Descriptive.)

18. Nees, C. G., Syst. d. Pilze II: 72. 1817. (Descriptive.)

19. Schweinitz, L. D., Syn. Amer. Fungi No. 2998. Trans. Am. Philo. Soc. n. ser. 4: 300. Fig. 4: 300. Fig. 4. (Descriptive)

20. Corda, A. C. I., Icon. Fung. Tom 1: 12. Fig. 175. Tom 2: 13. Tab. X. Fig. 61. (Descriptive.)

21. Corda, A. C. I., Icon. Fung. Tom 4:4. (Taxonomic.)

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Teaching experience: Teacher in public schools of Ness County, Kansas, 1908-9. Student teacher in Fairmount College Academy, 1913. Laboratory assistant, University of Kansas, 1913-14. Instructor in botany, Fairmount College, summer session, 1914.

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